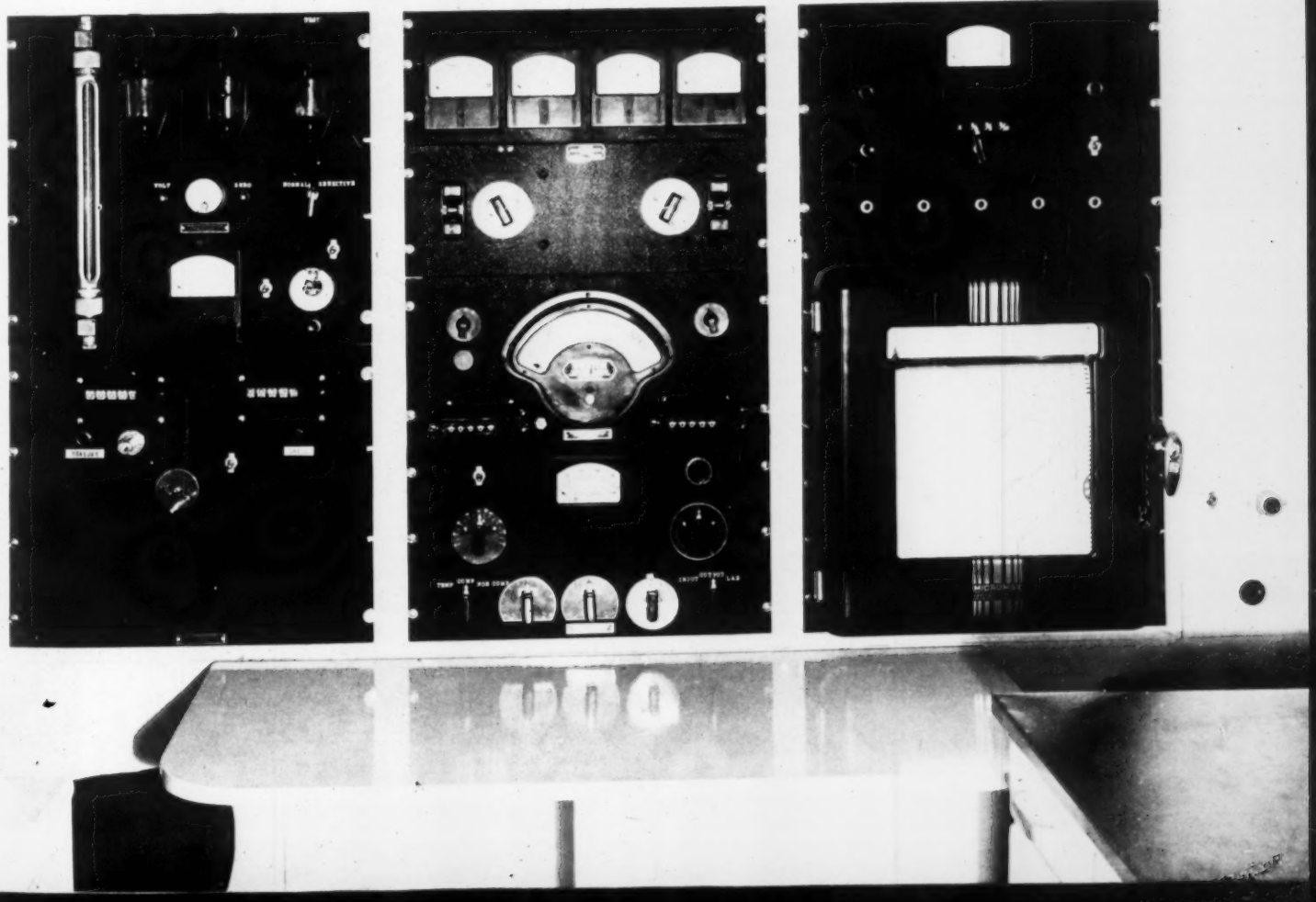
Instruments

THE MAGAZINE OF Measurement and Control

Vol. XIII
JUNE
1940
No. 6

JUN 17 1940



LOOK INTO THIS *NEW* CATALOG

SEND FOR YOUR COPY—IT'S FREE! LOOK INTO IT AND YOU'LL FIND

TEMPERATURE INSTRUMENT CLASSIFICATIONS
RECORDING THERMOMETERS—With 9", 10" and 12" Chart
MULTI-PEN RECORDERS
RECORDING HYGROMETERS AND SACCHAROMETERS
OVER 240 CHART ILLUSTRATIONS—Actual Size
ALL TYPES OF STAINLESS STEEL BULBS
VACUUM PRESSURE RECORDING GAGES
With 9", 10" and 12" Chart
HUNDREDS OF PRESSURE AND VACUUM CHARTS
AUTOMATIC AIR-OPERATED CONTROLLERS
On-Off and Throttling Types
RECORDER-CONTROLLERS
Temperature and Pressure
INDICATING CONTROLLERS
Temperature and Pressure
ELECTRIC-CONTACT INDICATING CONTROLLERS
ELECTRIC-CONTACT RECORDER-CONTROLLERS
DIAPHRAGM VALVES
Valve Positioner

Use the handy coupon below.

C. J. TAGLIABUE MFG. CO.
Park and Nostrand Aves., Brooklyn, N. Y.
Please send me a copy of the new TAG Catalog No. 1060-I.

Name _____ Title _____

Company _____

Street _____

City _____ State _____

C. J. TAGLIABUE MFG. C
Park & Nostrand Aves., Brookly N.

Measures FLUORESCENT and Other Types of Lighting Direct

(WITHOUT CORRECTION FACTORS)

WESTON DIRECT-READING FOOT CANDLE METERS

Regardless of the light source ... fluorescent, mercury-vapor, neon, sodium, tungsten ... you can measure the intensity direct in foot candles with inexpensive WESTON Foot Candle Meters. There is no calculating involved, for there are no correction factors necessary. These simple-to-use meters employ the famous WESTON-perfected VISCOR filter ... a stable, all-glass filter which corrects for all types of lighting regardless of color composition.

Full particulars on WESTON direct-reading Foot Candle Meters can be secured from the WESTON office in your vicinity, or by returning the coupon below.

* If you now have an unfiltered WESTON meter, it can easily be rebuilt to measure all light sources direct. The coupon will bring you full particulars.

Weston Electrical Instrument Corp.
591 Frelinghuysen Ave., Newark, N. J.

Send complete information on (please check which)

☐ WESTON *VISCOR filtered* Foot Candle Meters

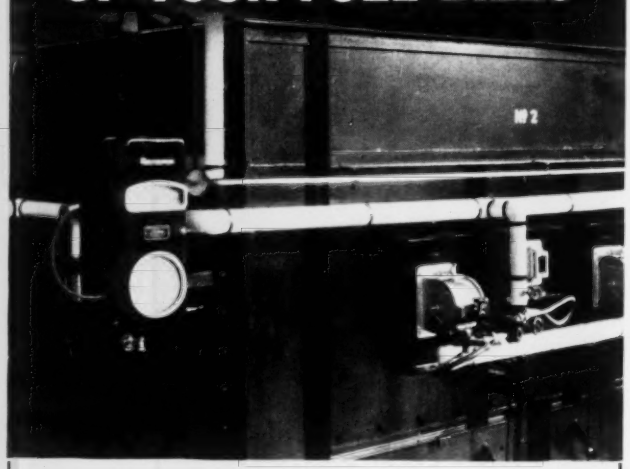
☐ Rebuilding my present model No. ..... Serial No. .....

Name .....

Address .....

City ..... *State* .....

MECHANICAL GUARDIAN OF YOUR FUEL BILLS



RANAREX

The Only Mechanical CO_2 Indicator and Recorder

On the job 24 hours a day, the Ranarex CO_2 Indicator gives you readings hot from the fire... so *fast* that you can open the furnace door and see the needle drop!

There are no orifices, fragile parts or chemicals in the Ranarex CO_2 Indicator and Recorder. It's ruggedly built, yet so simply that a screwdriver takes it apart. It's accurate within three-tenths of one percent of CO_2 — yet is unaffected by atmospheric conditions, vibrations or draft. Operates on lighting circuit. Portable models also available. Get free booklet showing how well-known firms have saved up to 10% on fuel with the Ranarex CO_2 Indicator and Recorder. Address The Permutit Company, Dept. A8, 330 West 42nd St., New York.

Product of PERMUTIT

Instruments

THE MAGAZINE OF MEASUREMENT and CONTROL

Vol. XIII JUNE 1940 No. 6

FRONT COVER: Instrument board, Baroid system for logging wells while drilling.
(See page 155)

EDITORIAL COMMENT 141

NEW INSTRUMENTS 142
Indicators, recorders, controllers, inspection devices, etc., for plant, field and laboratory.

THE ELECTRON MICROSCOPE 151
Theory and description, in brief
By V. K. Zworykin

INSTRUMENT LOGGING OF WELLS 155
Automatically, while drilling
By J. T. Hayward & L. M. Swift

PYROMETRY OF LIQUID STEELS 157
The graphite vs. silicon-carbide thermocouple
By G. R. Fitterer

PLANT INSTRUMENTATION 161
Wanted—a broader view
By W. H. Sayler

HARDNESS OF VARIOUS MATERIALS 162
Methods of measurement
By S. R. Williams

INSTRUMENTS' BOOK SHELF 168

*INSTRU*MERRIMENT 170

MANUFACTURERS' NEW LITERATURE ..... (Insert)

ADVERTISERS' INDEX ..... (Insert)

Published Monthly on the 15th by
THE INSTRUMENTS PUBLISHING COMPANY
1117 Wolfendale Street, Pittsburgh, Pa.

RICHARD RIMBACH, Managing Editor
M. F. BEHAR, Editor

BRANCH OFFICES
Boston: James Condon, 25 Brimmer St. (Lafayette 9769)
New York: R. K. Farnham, 118 E. 28th St. (Lexington 2-4637)
Chicago: William Farnham, 201 N. Wells St. (Andover 4180)
Cincinnati: Harold W. Haskett, Keith Bldg. (Main 4481)

Annual Subscription: U. S. $2.00. All other countries $3.00 *payable in advance* (remit by New York draft).

Copyright 1940 by The Instruments Publishing Company.

Entered as second-class matter January 26, 1932, at the post office at Pittsburgh under the Act of March 3, 1879.

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Education and Training Urgently Needed

"Civilization is a race between education and catastrophe."—H. G. WELLS
"Education is the defense of nations."—EDMUND BURKE

EVERY great emergency has caught our peace-loving American people unprepared. This one is no exception. Every emergency has suddenly brought to light new problems. This one is no exception: Today's technological difficulties differ greatly from those which American Industry surmounted in 1917-'18.

As an old doughboy, your editor holds that "the Infantry is the Queen of Battles" but America is not at war and—though elsewhere we preach universal military service—we recognize that America's immediate problem is to transform her potential power into actual "ready-to-use" power.

This is a tremendous task. In spite of America's huge potential capacity, the production of great fleets of tanks, airplanes and naval vessels is impeded by an acute shortage of men—not of ordinary workers but of specialists.

The scarcity of skilled mechanics is already publicized in newspapers and in the periodicals serving affected industries. There is a corresponding dearth of skilled instrument makers, instrument maintenance men, etc. This is serious, but fortunately it is no news to the Army and Navy industrial boards. Most critical of all, however, is the shortage of Instrumenticians: of thoroughly educated engineers capable of solving fundamental problems and overcoming difficulties through the scientific application of measurement and control to munitions production.

For years we have urged that technical schools give basic Instrumentation courses and that Chairs of Instrumentation be established in engineering schools. We preached this persistently, but perhaps too dispassionately. We sent questionnaires to engineering schools and universities and did not fly into a patriotic rage when meager returns betrayed general indifference. We talked about such courses with Deans of Engineering and did not explode when they laughed in our face at our assertion that the hierarchy from "chart boy" to Instrument Engineer parallels that from "grease monkey" to Aeronautical Engineer. The time has come to speak plainly. *We declare that it is the DUTY of American engineering schools to inaugurate thorough courses in Instrumentation NOW.*

But that is not enough. What of the young or insufficiently-trained instrument men now employed? In every industrial center, evening courses—both elementary and advanced—should be inaugurated without delay. This can be done in a number of ways, from the most formal to the most informal. No doubt, some plant executives will help organize courses for employees and will provide facilities. No doubt, some boards of public education, with Federal funds[1] or without, will do likewise in collaboration with plants. The need is so urgent, however, that we recommend the plan which was spontaneously started by a group of instrument men in and around Pittsburgh more than a year ago, and which has now become known as The American Society for Measurement and Control.

News of this society has been briefly reported on this page[2]; but circumstances justify repetition. Early in 1939 a group of ambitious young instrument men in and around Pittsburgh began meeting regularly in order to discuss various phases of instrumentation—in order to learn more about their work. We did not know of their existence until August 1, 1939. At that time, they numbered around twenty. An evening course was to have been given at Carnegie Tech beginning last autumn but it had to be cancelled because of the instructor's illness. Since last January, two meetings each month have been held in Pittsburgh: one open technical meeting and one closed "educational" meeting (the latter devoted to a prepared lecture later mimeographed and distributed to all paid-up members in and out of town). Membership grows steadily.

Let a "chapter" or an independent group be organized in every industrial center, let it run its own affairs in its own way; and let the future take care of affiliation.

Are you interested? Then pick up your 'phone, call a meeting of your instrument-minded friends and get started right away! Invite the instrument engineers in your vicinity to give informal talks and answer questions.[3]

Never mind about an ideal curriculum until your local group has begun to sink its teeth, more or less at random, into various phases of the science of Instrumentation. A really thorough course would correspond to The Manual of Instrumentation—half a million words of which have already appeared in instalments in this magazine!—so you might leave the careful planning of comprehensive courses to the colleges and universities.

Having lined up a group and signed up lecturers and discussion leaders, give serious thought to the early *coöperation* by your group with local manufacturers' associations; with personnel managers' associations; with universities, colleges and boards of education; and particularly with the local chapters of existing engineering societies[4] and with the nearest District Offices of the Army's and Navy's industrial procurement services.[5] Your group can before long be of service to these established agencies in your community or region; and reciprocally they can provide facilities, or tell you of subjects requiring special study, or otherwise help the movement.

[1] See article on cooperative course at Charleston, W. Va., by C. B. Cochran; *Instruments*, April 1939, pages 110-112.

[2] August 1939, page 203; Nov. 1939, page 283 April 1940, page 87; May 1940, page 113.

[3] If you are an experienced Instrumentician, offer your services without waiting to be "discovered." Moreover, each local group will be an ideal common ground for users and sales engineers.

[4] Following the publicity given to the election of officers by the A.S.M.&C., a little interchange of correspondence took place between officers of the A.S.M.&C. and the A.S.M.E., the outcome being complete understanding and harmony: all concerned now agree that the A.S.M.&C. is not a society of professional engineers. To quote one of President Pigott's letters, "The A.S.M.&C. is not limited to engineers who would be able to qualify in the A.S.M.E. It is aimed chiefly at encouraging the interest and training of a considerable group of men who are engaged in the choice, installation and operation of measurement and control instruments, but many of whom have—neither the experience nor the technical training to qualify in the A.S.M.E., and some of whom, particularly the operating group, never would be able to qualify. . . . I do not think the operations of this new society should interfere with anything the A.S.M.E. is doing." Your editor believes that the new movement will act as a "feeder" for engineering societies.

[5] For example the Army Ordnance Dept. has 11 District offices

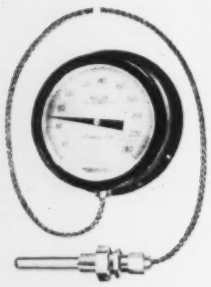
MOELLER
PRECISION GRADE INSTRUMENTS

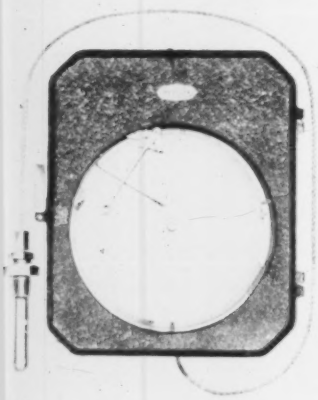
★

Moeller mercury thermometers are made with the Moeller Glass Red Reading Column making them easy to read under varying light conditions, at a considerable distance and over a wide range.

★

Moeller dial thermometers are made in various scale ranges up to 1000°F. or equivalent. Metal and Phenolite cases.





Moeller recording thermometers are likewise furnished in various ranges up to 1000°F. or equivalent. Round and square cases as preferred.

Also HYGROMETERS
RECORDING PSYCHROMETERS
BAROMETERS HYDROMETERS
MARINE INSTRUMENTS, ETC.

Write for catalog.

MOELLER INSTRUMENT COMPANY
132nd STREET and 89th AVENUE
RICHMOND HILL NEW YORK

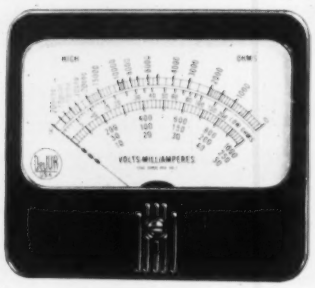
Sales Representatives in Principal Cities

THE MONTH'S NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

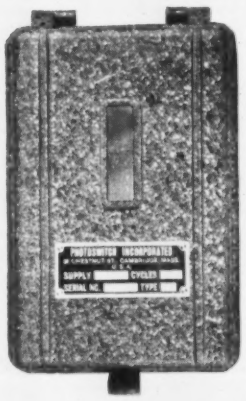
New Line of Electrical Measuring Instruments

The DeJur-Amsco Corporation announces its entrance into the electrical instrument manufacturing field; states that it is "now in production on a complete line" of ammeters, microammeters and voltmeters in 2", 3" and 4" sizes, round and square cases.



This line is primarily intended for manufacturers of radio, recorder, transmitter, service and miscellaneous electrical equipment.—*DeJur-Amsco Corp., Shelton, Conn.*

Electronic Pilot Relay



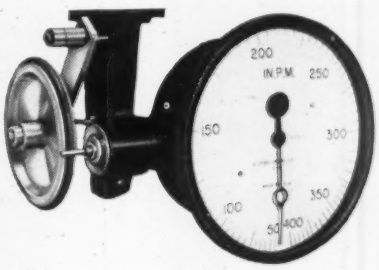
New "Photoswitch Pilot Relay" is a device whereby, it is said, "only three millionths of an ampere may control any current desired." It is described as "an electronic switch for control of large currents by delicate mechanisms, liquids or light contact pressure." — *Photoswitch Inc., 21 Chestnut St., Cambridge, Mass.*

Go & No-go Gages

Go and no-go gages tipped with "Kennametal" are now available for gaging cylinders, tubing, etc. They consist of notched steel blanks with small pieces of Kennametal brazed at both ends where the work is measured. Difference in width between go end and "no-go" end on the two gages illustrated is 0.002". Gages can be made to measure any practical tolerance in almost any diameter.—*The McKenna Metals Co., 301 Lloyd Ave., Latrobe, Pa.*

Stationary Tachometers

New line of 6" dial stationary tachometers with hand-graduated scales is announced. Attachments permit measuring r.p.m. (directly or through speed-changing), inches per minute, etc., of shafts or of materials in motion. Mechanisms (centrifugal type) can be supplied whereby scale maximum is from 2 to 40 times minimum speed, as specified. Net weight of instrument and bracket being 2¾ lbs., it can be used as a hand tachometer. Other features: dead-beat indications, accuracy 0.5%, full ball-bearing construction.—*O. Zernickow Co., 15 Park Row, New York City.*

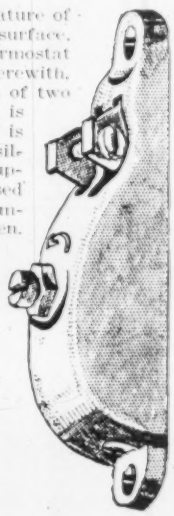


Multi-range Tester

Latest addition to maker's line of test equipment is new "Series 832," a 31-range, rotary selective a.c.-d.c. multi-range tester. The 3⅝" indicator is said to be "the largest ever incorporated in small, popular priced multi-range testers." Six d-c. voltage ranges at 1000 ohms per volt up to 1200 volts; 6 a-c. ranges at 500 ohms up to 2400 volts; 4 d-c. current ranges to 1200 milliamps; 3 ohmmeter ranges to 5 megs. (to 500 M ohms on internal 3-volt battery); 6 decibel ranges (—10 to +62); 6 output ranges to 2400 volts. Hardwood case with self-contained batteries. Size 7" × 4½" × 3".—*Precision Apparatus Co., 647 Kent Avenue, Brooklyn, N. Y.*

Strip Type Thermostat

For controlling temperature of electrically heated flat surface, new "NS" strip type thermostat is placed in contact therewith, being attached by means of two 10-32 screws. Housing is cast aluminum. Element is bimetallic; it actuates silver contacts which are supplied either normally-closed (to open with rise of temperature) or normally open. Differential is 5°F.; rating is 1500 watts at 115-230 volts a.c. Two ranges are available: 0-350°F. or 350-700°F. Control point is adjusted by turning locking screw. Dimensions 3⅝" × 1" × 1".—*George Ulanet Co., 88 East Kinney St., Newark, N. J.*



THE RIDER CHANALYST established signal tracing! It was the first instrument of its kind and still is the top instrument! Dollar for dollar the RCA Rider Chanalyst offers the most for the money.

The present-day RCA Rider Chanalyst is the result of years of development based on a wide range of receiver circuit knowledge, test equipment application, and country-wide contacts with the servicing fraternity. Every possible arrangement of meters, "eyes," and other type indicators was tried. The final version of the RCA Rider Chanalyst offers the greatest amount of utility and flexibility combined with built-in stability and freedom from complicated circuits at the lowest price.

For instance: Five separate channels are available *simultaneously*, permitting the isolation of intermittent troubles—most difficult to discover—in the shortest possible time. The RF-IF channel is a 3-stage tuned r-f amplifier—resonated vacuum tube voltmeter type—assuring adequate sensitivity and selectivity. A calibrated meter—automatically protected against normal overloads—is arranged to function in 4 channels at the option of the operator. The use of inertia-less "electronic eyes" as indicators affords the greatest speed of action for fast servicing since the "eye" provides an easily observed signal level permitting stage gains to be read directly from level control.

RCA RIDER CHANALYST
$107.50

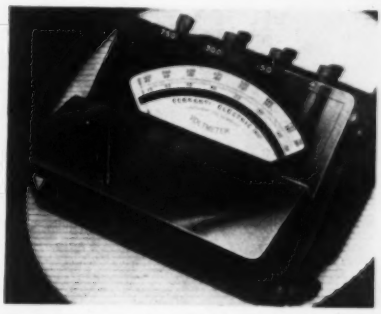
net. F.O.B. Camden, New Jersey
It will pay for itself by saving your time . . . upping your profits.

Over 335 million RCA Radio Tubes have been purchased by radio users . . . in tubes, as in parts and test equipment, it pays to go RCA All the Way.

RCA
Test Equipment
RCA Manufacturing Company, Inc., Camden, N. J.
A Service of the Radio Corporation of America

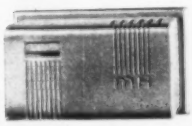
Portable 3-range Voltmeter

New "Model 956" is announced as "a precision testing instrument for industrial and central station use, and for all service and field testing work." It comes in a black walnut case fitted with hinged cover and carrying strap. Though designed for a-c. circuits, it may be used on d-c. circuits with slight sacrifice in accuracy. It conforms to A.I.E.E. and N.E.M.A. specifications, meets Army and Navy specifications, is manufactured in the U.S.A.—*Ferranti Electric, Inc., 30 Rockefeller Plaza, New York City.*



Humidity Control

New "HO900 Room Humid-U-Stat" pneumatic type humidity controller employs a human hair element extremely sensitive to changes in relative humidity. Instrument is equipped also with a temperature compensator. Another feature is universal adjustment whereby Humid-U-Stat may be used as a direct-acting or reverse-acting control, and whereby throttling range may be adjusted on the job to prevent overshooting and hunting. Instrument is available in scale range of 20% to 80% relative humidity with scale markings 20, 50 and 80. Throttling range is adjustable from 2% to 30% relative humidity. Instrument may be mounted flush on a wall box or on surface of a surface box.—*Minneapolis-Honeywell Regulator Co., 2950 Fourth Avenue South, Minneapolis, Minn.*



Multi-purpose Industrial and Aviation Watch

New "960 Multi-purpose Chronograph" has not only all features of preceding models (see *Instruments*, May 1939, page 136; January 1940, page 31) but is said to incorporate new features never before offered. It is shockproof, dustproof, waterproof, and non-magnetic. Six different dials are available, including industrial styles. New "Bezelmeter" feature, a free-turning bezel graduated 12 h. in 15-m. divisions, shows unelapsed time, i.e., time remaining in an industrial operation, on a flight ("remaining gas time"), etc. Illustration is full-size.—*Jardur Import Co., 21 West 19th St., New York City.*

BAILEY METER CONTROL SYSTEM

The Mark of
Effective Control

Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

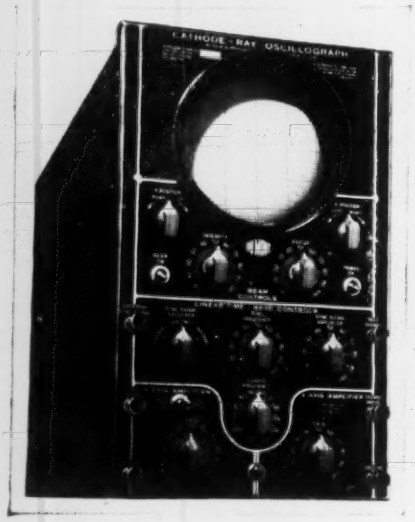
Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY
1041 Ivanhoe Rd., Cleveland, Ohio

Cathode-ray Oscillograph

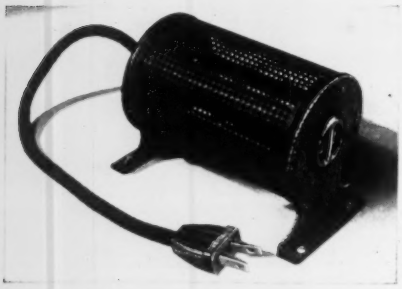
New "Type 208" cathode-ray oscillograph is said to embody "many improvements and refinements." It is supplied with an intensifier-type cathode-ray tube utilizing electrostatic focusing and orthogonal electrodynamic deflection. "Unusually high-gain" amplifiers have been provided for deflection on both horizontal and vertical axes, while a gas-discharge type relaxation oscillator provides the time-base sweep circuit. New construction is said to permit short low-capacity low-impedance leads between all circuits. Controls are grouped, physically and electrically, on front panel. It is said that all annoying position-changes of pat-



tern on screen, due to attenuator adjustment, are eliminated. Frequency response rating of instrument is independent of attenuator settings, and low-frequency signals with high-frequency components may be studied at attenuated gain settings with no distortion of amplitude and phase relationships of signal components. A new deflection-amplifier coupling circuit eliminates "electrical backlash" in position-control circuits. High-frequency signals may be expanded horizontally and studied on a time base nearly 15" long. Other features: Constant-impedance, continuous-input attenuator with no frequency discrimination; beam switch; symmetric deflection of both axes; undistorted four-cycle square-wave response; amplifiers flat to 100,000 sinusoidal cps.; sweep frequency range of 2 to 50,000 cps.; instantaneous positioning circuits.—*Allen B. Du Mont Labs., 2 Main Ave., Passaic, N. J.*

General-utility Resistors

A line of general-utility voltage-dropping resistors, "Series HT," comprises units in any resistance and wattage rating from 100 watts up. Each is built around a "Clar-



ostat Greenohm" power resistor, is housed in a 3" diameter perforated metal shell 11½" long, with mounting feet, for the 100-watt size.—*Clarostat Mfg. Co., Inc., 285-7 N. Sixth St., Brooklyn, N. Y.*

Rawson Twin Multimeter

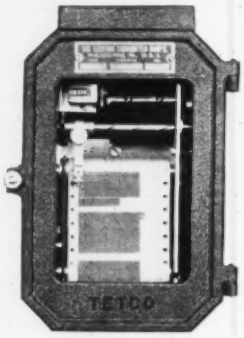
29 ranges in less space than any near equivalent combination—
size 12" x 8" x 6"

RANGE OF MEASUREMENTS
D.C. 1 microampere to 1 ampere
20 microvolts to 1000 volts
A.C. (up to 3000 cycles)
2 milliamperes to 3 amperes
60 millivolts to 1000 volts

Special apparatus built to order

RAWSON ELECTRICAL INSTRUMENT COMPANY
110 POTTER ST. CAMBRIDGE, MASS.
Branch: 15 East 26th St., New York City
Representative: E. N. Webber
1313 W. Randolph St., Chicago, Ill.

TETCO
Speed Recorder



Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.

The Electric Tachometer Corp.
1358 Spring Garden St., Philadelphia, Pa.

Vacuum - - - Thermocouples
featuring
DEPENDABLE STABILITY
HIGHER OVERLOAD
FASTER RESPONSE
Our thermocouples will meet the most rigid requirements. Write your requirements to—
American Electrical Sales Co., Inc.
67 E. 8th ST. NEW YORK, N. Y.

★ *NATIONAL* ★
RHEOSTATS
Ask for Catalog No. 5
National Electric Controller Co.
5317 Ravenswood Ave., Chicago, Ill.

Odometer for Surveying

New "Model S-20 Foot-Odometer" per measuring, in feet, distances covered motor vehicle in which it is installed. C plete equipment includes odometer, steeri post bracket, drive cable and a new d drive adapter. This adapter makes it po ble to have two cables for transmission for usual speedometer, the other for Fo Odometer. Adapter is available in a "hi number" of gear ratios to obviate neces of keeping in mind a correction factor. M ufacturer explains it as follows: "For ample: After installing the Foot-Odomet on your car, if you should find that over known distance of 1,000 feet, your Foo Odometer only recorded 980 feet, we wou

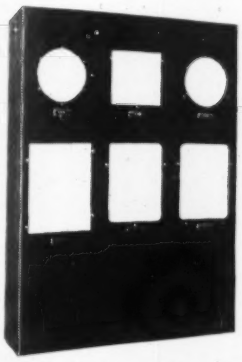
send you a 2% increase adapter in exchang for yours, which would increase the r.p.m. of the Foot-Odometer cable 2%, thereby correcting the error. The r.p.m. of the speedometer cable would remain unchanged. Thereafter, an error though present in your speedometer reading, would not be reflected in the Foot-Odometer reading." New model instrument is available with "subtraction" feature providing decrement of reading when car is driven in reverse gear. It is also available with "fast-reset feature" without subtraction, which can be set to zero with two turns of the reset stem. Since pointer turns counter-clockwise when car is being operated in reverse gear, a certain amount of subtraction (maximum 99 ft.) is available with "fast-reset odometer" before black figure wheels automatically rotate backwards toward zero. This rotation starts when any of the red figures in the tenth dial match up with any of the black figures in the other dials.—*Speedometer Electric Co., 699 Van Ness Ave., San Francisco, Calif.*

Multi-range "Clipon" Ammeter

New Multi-range "Clipon" Ammeter has five full scales: 0-10/25/100/250/1000 amps., with only one set of scale divisions, all full

scales being multiples of 10 or 25. Instrument is said to be well balanced and easy to operate. It has a 2¼" rectangular opening which makes it adaptable for use on square busbars as well as round cables.—*Ferranti Electric, Inc., 30 Rockefeller Plaza, New York City.*

FALSTROM



STEEL PANELS

FALSTROM Precisioned Steel Panels are specified by engineers for their Strength . . . Durability . . . Fine Appearance . . . for use in—

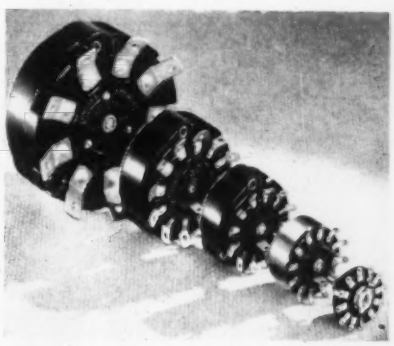
POWER PLANTS
OIL REFINERIES
PUBLIC UTILITIES
PROCESS INDUSTRIES
COMMUNICATIONS

Send blueprints. Write for bulletin P-6

FALSTROM COMPANY of PASSAIC N. J.

Rotary Selector Switches

Maker's line of "Power Tap-Switches" (see *Instruments*, June 1939, page 150; Aug. 1939, page 240; Sept. 1939, page 252) is expanded by addition of increased-rating models as follows:

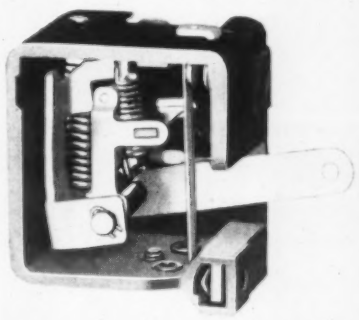


Model	111	212	312	412	608
Amps.	10	15	25	50	100
a.c.v.	150	150	300	300	300

These ratings apply to a-c. circuits operating at any power factor.—*Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.*

Sump-pump Float-switch

New float-switch designed specifically for sump-pump control is a single-pole switch employing an overcenter toggle mechanism. Float-rod weight is counterbalanced by a



calibrated spring acting on operating lever. Other features include corrosion-resistant snap-action mechanism, accessible terminals, a dummy terminal to provide convenient wiring of "through" side of line, and fine-silver contact tips.—*General Electric Co., Schenectady, N. Y.*

Non-inductive Resistors

To take care of applications calling for non-inductive resistors capable of handling appreciable power, new "Series Z" resistors are claimed to have the least inductance of any

presently available non-inductive resistors, are available in these wattages and resistance ranges: 10-watt, max. res. 3000 ohms; 25-watt, 7500 ohms; 50-watt, 12,500 ohms; 100-watt, 25,000 ohms. (For one-half these power ratings, multiply maximum resistance available by four.)—*Clarostat Mfg. Co., Inc., 285-7 N. Sixth St., Brooklyn, N. Y.*

A Complete THERMOCOUPLE Catalog JUST OFF THE PRESS

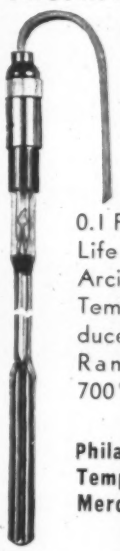
Helpful information and recommendations to help you choose the right Thermocouple and accessories for your specific application.

★ Complete listing of Thermocouples — Protecting Tubes — Lead Wires — Insulation heads — Accessories, etc.

Write for your copy today!

Wheelco Instruments Co.
1929-33 S. HALSTED STREET · · · CHICAGO, ILLINOIS

Philadelphia Merc-to-Merc Thermo-Regulators Feature



Mercury to Mercury Contacts : Increased Contact Capacity : Sensitivity within 0.1 F. Exceptionally Long Life and Stability : No Arcing : No Oxidation : Temperature Lag Reduced : Temperature Ranges adjustable to 700°F.

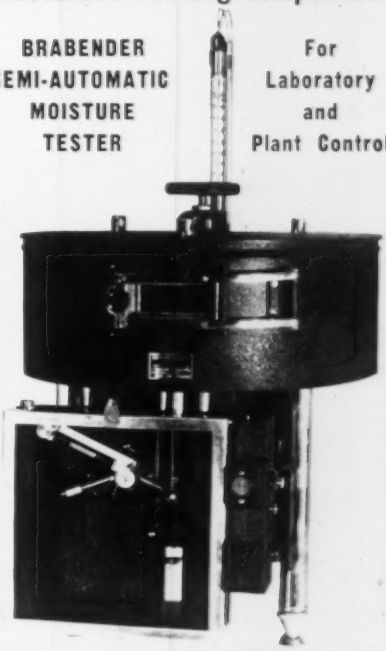
Philadelphia Merc-to-Merc Temperature Controls and Mercury Plunger Relays

The Philadelphia Thermometer Co.
915 Filbert Street -:- Philadelphia
WRITE FOR CATALOGUE No. 104.
Oldest Thermometer Manufacturer in Philadelphia

Moisture Testing Simplified

BRABENDER SEMI-AUTOMATIC MOISTURE TESTER

For Laboratory and Plant Control



An ideal combination of drying oven and analytical balance. Requires no training—just push down a lever and read the moisture loss from an illuminated dial—directly in percentages.

Accuracy—1/20th of one percent. Capacity—Ten 10-gram samples. Temperature Range—85° C.-175° C. Moisture Range—0%-100%. Heating Capacity—750 Watts. Operating Current—110 volts, 60 cycles. AC 125 cycles if required. Heating up time—5 to 10 minutes.

Write for pamphlet

BRABENDER CORPORATION Rochelle Park New Jersey

Magnetic Gas Valves

Developed for control of diaphragm valves, safety pilots, gas humidifiers, etc., a series of single-port magnetic gas valves is announced, comprising four sizes: $\frac{1}{8}$", $\frac{1}{4}$",

$\frac{3}{8}$" and $\frac{1}{2}$". Operation is by flapper type armature. Valve port has metal-to-metal ground face, with self-adjusting valve made of Monel. Internal parts are electrically tinned to guard against corrosion. Valves can be supplied in line voltage (110 v.) or low voltage (20 v.). They are said to be silent in operation.—*Julien P. Friez & Sons, Baltimore & Central Ave., Baltimore, Md.*

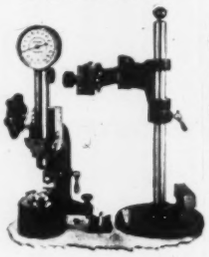
Plug-in Type Capacitors

Announcement is made of plug-in electrolytic capacitors developed primarily for the U. S. Signal Corps and offering advantages to aircraft, police-radio and sound-system

equipment where continuity of service is of paramount importance. New capacitors represent solutions of problems such as hermetic sealing, absolute elimination of leakage or seepage of electrolyte, and prevention of internal or external corrosion due to joining dissimilar metals. A special octal base has nickel-plated brass prongs joining with aluminum studs, junction being imbedded in molded Bakelite plug. All external metal parts are nickel-plated brass, all internal parts aluminum. The can may be negative or at cathode potential, thus acting as a shield in preventing radiation of interference voltage, or may be left floating. New plug-in units cannot be incorrectly connected. Servicing operations are materially simplified. "Series AP" plug-in electrolytics are available in either etched foil or plain foil, in two can diameters, $1\frac{3}{8}$" and 1-5/32" dia., and in heights from $2\frac{1}{2}$" to $4\frac{1}{4}$". One to three sections can be included in the cans, using number pin for common negative, or if desired, four sections can be included with the container as common negative.—*Aerovox Corp., New Bedford, Mass.*

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 30 years.

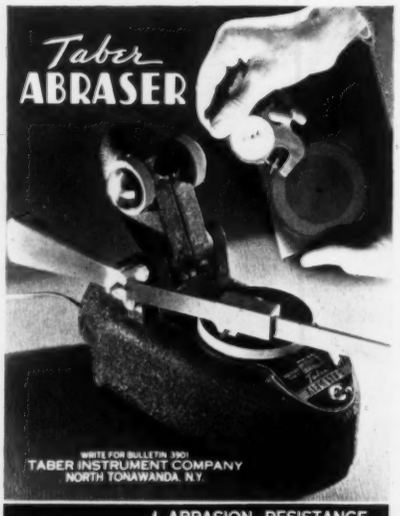


In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

Illustrated bulletins free.

The Shore Instrument & Mfg. Co., Inc.

9025 Van Wyck Avenue, Jamaica, N. Y.



Taber ABRASER

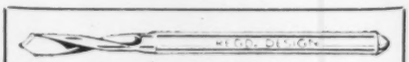
ABRASION RESISTANCE
PLASTICS • ORGANIC COATINGS
ELECTROPLATE • TEXTILES
SHEAR HARDNESS
PLASTICS • ORGANIC COATINGS

TRU-VAC
VACUUM GAUGES
(PIRANI TYPE)

Priced From $39.50

Circular on Request.

CONTINENTAL ELECTRIC CO.
GENEVA, ILLINOIS



SMALL DRILLS

from .0016 up to .1969 inch diameter, all sorts of small turned parts. Small wood screws in brass, steel, etc., turned from the bar.

BLACK GRINDING DISCS

H. C. M. ENGEL, Inc.
P. O. BOX 233, SIDNEY, NEW YORK

Liquid Level Telemetering System

Outstanding characteristics of new liquid level telemetering system are: (1) standardization on five ranges, permitting quantity production of dials, gear sets, etc., and

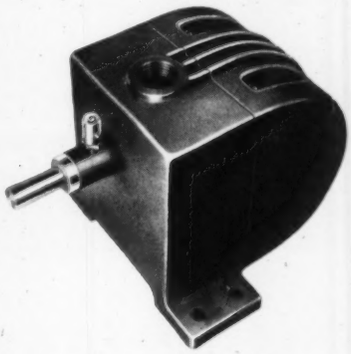


Fig. 1.

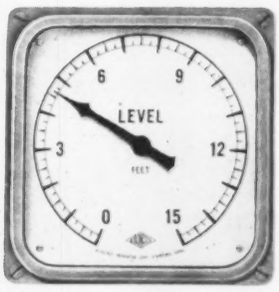
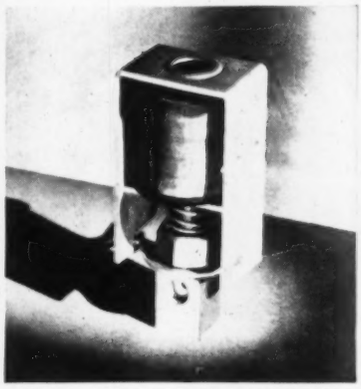


Fig. 2.

consequent low prices; (2) standard weatherproof transmitter, Fig. 1, suitable for all exposures; (3) standard $7\frac{1}{2}$" square case indicator designed for flush mounting; (4) unconditional one-year guarantee. System employs maker's self-synchronous motor principle. Standard float is a heavy-gage copper cylinder $8\frac{1}{2}$" diam.; other accessories have likewise been standardized, but many different items remain available.—*Electric Indicator Corp., 21 Parker Ave., Stamford, Conn.*

Solenoid Valve for Air-conditioning Control

New solenoid valve adapted to requirements of the heating and air-conditioning industry as well as to general applications in control of air, oil, water, and gas, may



be used as water control for humidifiers, oil shutoff for oil-burner service, pilot-gas control for gas burners, air control for compressed-air devices, etc. Since it is designed to be incorporated into an assembly that has its own enclosure, no coil cover, conduit plate, etc., have been provided.—*General Electric Co., Schenectady, N. Y.*

hermometers
Hygrometers
Psychrometers
Hydrometers

Several hundred types and varieties of instruments are described in new Catalog 110, but since ALL of them are produced in our own factory under our own experts' supervision, the best materials and high-grade workmanship characterize EACH of them.

Our customers find special satisfaction in the choice of FOUR different styles of thermometer glass: 1. White enamel back; 2. yellow enamel back; 3. Hespe; 4. red-reading mercury.

TWO WIDELY USEFUL NUMBERS

(Left) No. 169. For pressure-cooking processes, with two scales: 170-270°F. and 0-30 lbs. pressure. 9" scale length.

(Right) No. 326. Max. & min. registering thermometer in 12" shelter type copper case. Approx. range minus 40 to 120°F.

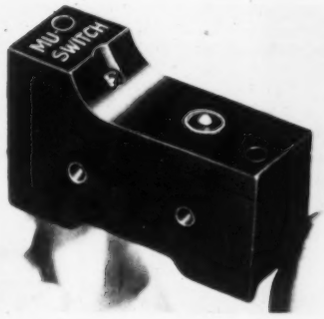
Weksler Thermometer Corporation
535 PEARL STREET NEW YORK, N. Y.

Quinhydrone pH Meter

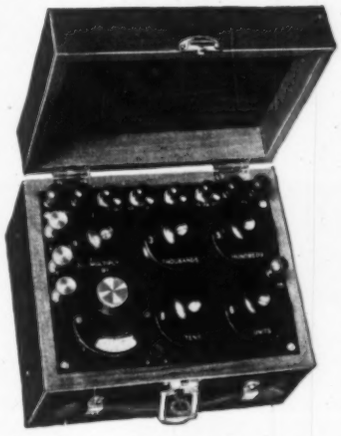
New Beckman Quinhydrone pH Meter is said to be unusually rugged and compact. It has been especially designed for applications that permit use of quinhydrone electrode. Electrical parts are built into chemical-resistant molded black plastic case. Indicator is located in top of case for ease of reading. All operating controls are grouped on front panel. The single flashlight cell required for operation is also contained within case. Range is 0 to 9 pH in 0.1 graduations. Scale is said to be so designed that it gives direct temperature-corrected readings without use of temperature correction tables or calculations. A magnifying lens mounted above dial facilitates close reading of scale. Both the quinhydrone electrode and the KCl—Calomel reference electrode are of molded plastic construction, equipped with plug-in connections. Complete equipment is mounted in a fabric covered carrying case $11\frac{1}{2}$" × $4\frac{1}{2}$" × 7". Instrument slides upon a ringstand rod attached vertically to carrying case so that no other support stand is required. If desired, meter can be quickly removed from case for direct immersion of the electrodes into tanks, vats, etc.—*National Technical Labs., 820 Mission St., South Pasadena, Calif.*

"Millibreak" Switch

Handling a d-c. load of 17 amps., at 125 volts, or 8.5 amps. at 250 volts, new "Type D Mu-Switch" makes available "for the first time" it is said, a means of directly controlling relatively heavy non-inductive loads on d.c. with an actuating pressure of 24 oz. & actuating movement of 0.0015". Among applications: thermostatically controlled electric heaters, solder pots, glue pots, etc. Switch measures 2-5/16" long, 13/16" wide, $1\frac{3}{8}$" high. With its contacts made of a "special non-sticking alloy," and having a magnetic blow-out device for arc suppression, switch does not need capacitors or resistors to protect the contacts. Housing is molded in a plastic capable of withstanding 300°F. One-piece beryllium copper spring member utilizes the reverse-action, cross-center principle. — *Mu-Switch Corp., Canton, Mass.*



PORTABLE
WHEATSTONE BRIDGE



A high grade instrument for measuring resistances from a fraction of an ohm to 10 megohms. Contains a 4-dial rheostat, ratio dial, galvanometer and battery, all enclosed in a substantial walnut case. Nine coils per dial. Accuracy .1%. Built to endure.

Cat. No. 1050—Portable Wheatstone Bridge with Murray and Varley Loops . . . $110.00
Cat. No. 1052—Portable Wheatstone Bridge without Murray and Varley Loops $90.00

Send for Bulletin No. 105

RUBICON COMPANY
Electrical Instrument Makers
29 North 6th St. Philadelphia, Pa.

Wheelco
PROPORTIONING CONTROL

● Designed for use where variable fuel input is required to maintain constant temperature, the proportioning system is built integrally into the Wheelco CAPACITROL "Radio Principle" Controller. Operating function is entirely electrical, resulting in instantaneous response and maximum accuracy. Wide open, easily read dial.

Wheelco Instruments Co.
1929-33 S. HALSTED STREET · · · CHICAGO, ILLINOIS

FOR ALL SCIENTIFIC USES
GALLET
GUINAND
and SECURITY
TIMERS

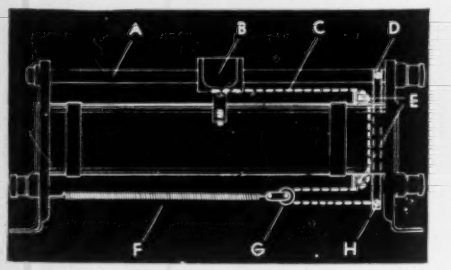
The Widest Selection of **TIMERS** and **CHRONOGRAPHS**
Best Quality in every Price Range

FREE Catalog on request

JULES RACINE & CO.
20 WEST 47th ST., NEW YORK

Tubular Rheostat with Pigtail Connection

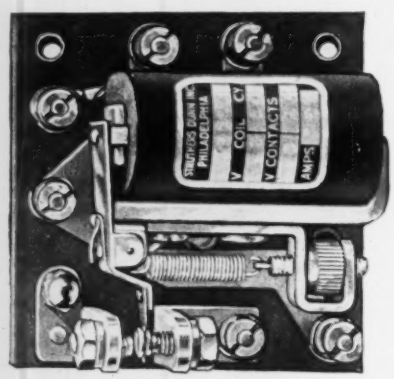
A new tubular rheostat with overbridged contact-resistance at the slider bar is announced. Purpose, use in laboratories, factories, mines, ships, etc., where slider bar will be covered with a layer of dust, grease and oxides which impedes flow of current.



If rheostats are to be used, for measurements or calibration, variable contact resistance becomes extremely objectionable. This variable contact resistance has been eliminated in new tubular slide-contact rheostat illustrated. Contact brush B is attached to flexible metal cord C, shown dotted, which goes over two parts of insulated material E, and over wheel G. Spring F, connected to wheel, gives cord necessary permanent tension. If slider knob B is moved from right to left, wheel G travels half the distance from left to right, and vice versa. The other end of cord C is directly connected to the slider bar A by rod D—H. Using an insulated wheel, ohmic value of cord C overbridging contact resistance at slider bar does not change with position of slider knob. Block-and-pulley enables application of a long spring F which has hardly any noticeable effect upon movement of slider knob. Slider bar is only for mechanical guidance of slider knob, and therefore it can be made of any material desired, which will not be affected by ambient conditions.—*Rex Rheostat Co., 37 West 20th St., New York City.*

Sensitive Relays

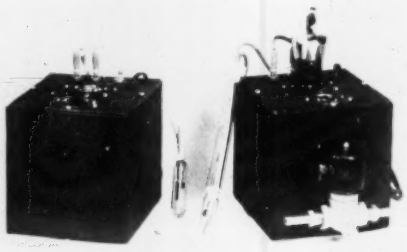
New "Dunco Type Sensitive Relays" are said to have been specifically designed for applications "where a high degree of sensitivity must be coupled with high-speed, low-power operation." They operate on 0.008 watts, d.c.; or 0.10 v-a. at 60 cycles a.c.; and will operate on ¼ of rated power where reduced contact pressure is permissible. They are said to afford an "exceptionally wide" current and voltage range and to be especially suited for use with sensitive control units such as mercurial thermostats,



etc. "Stay-put" micrometer adjustment and balanced construction are said to assure dependability even where vibration is encountered. Two types are available, (1) having contacts separate from coil circuit for general applications and (2) with contacts interconnected with the coil circuit for use with contact-equipped galvanometers or sensitive mercurial thermostats.—*Struthers Dunn, Inc., 1315 Cherry Street, Philadelphia, Pa.*

Two-unit Thermoregulators

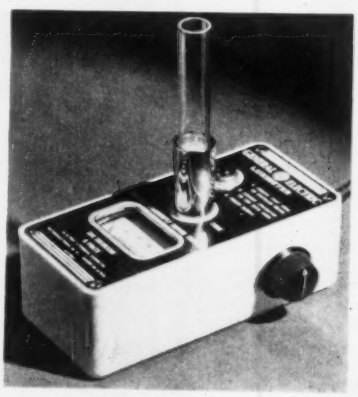
New systems for automatic temperature control of constant-temperature baths, etc., consist of two units: (1) glass-sealed non-adjustable bimetallic thermostats known as



"Thermoletts"; (2) electronic relays of 2500-watt capacity, known as "Thermolettors." Two forms of "Thermoletts" are available: "TL" (shown at left) is 2½" long, is intended for use in a thermometer well or socket; "TL" (at right) is 10" long and is recommended for use where convenience of handling is desired. Two types of "Thermolettor" relay boxes are available; at left, the laboratory type; at right, "type LG-300" which incorporates a ⅜" electrically-operated valve for gas, water or moderate-pressure air. Announcement lays stress on inexpensiveness of glass-sealed "Thermoletts" and recommends use of a number of them, with different control points.—*Standard Controls, 381 Fourth Ave., New York City.*

Cane-juice "Luximeter"

Originally designed for determining degree of pasteurization of milk, maker's "Luximeter" is also being used successfully, it is said, to determine clarity or turbidity



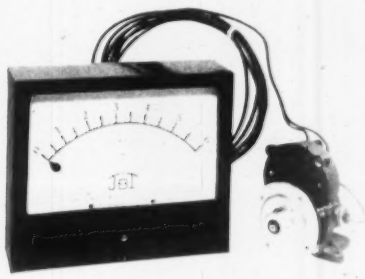
of cane juices going to evaporators, and of filtrate from filter presses. "Luximeter" consists of a light source, a light sensitive cell, and an indicating instrument all in one unit. Light source is regulated by a rheostat and directed through a test tube containing the solution to be measured. Transmitted light falls on photocell.—*General Electric Co., Schenectady, N. Y.*

Smaller Dual-section Midget Electrolytic Capacitors

Smaller dimensions and two independent sections with four leads distinguish new "PRS Dual Dandees" just added to maker's line of midget-can electrolytics. Dual "PRS 450 8-8" and "PRS 250 16-16" measure 1" × 2½"; "PRS 150 20-20" measures 1" × 2¼". These dimensions are believed to be the smallest for any dual midget electrolytics of corresponding voltages and capacities now available. Units have two entirely independent sections and four leads, permitting independent use of either section and either common positive or common negative connections.—*Aerovox Corp., New Bedford, Mass.*

Electric Tachometer

New "Model 75-T" electric tachometer consists of a d'Arsonval type d-c. [illegible] milliammeter (made to J-B-T specifications) and a d-c. magneto designed to be run at normal maximum of 1,000 r.p.m. [illegible] minimum top speed of 200 r.p.m. Instrument, however, may have scale cor[illegible]



ing to true shaft speed when gearing is used between shaft and magneto. Instrument is housed in cast aluminum case 7" × 6½" × 2½", finished in velvet black. (White plastic case available on special order for food processing machinery.) No. 14 B&S copper wire (not supplied) is used to connect the magneto to the instrument. Lengths up to several hundred feet are feasible. Calibration is said to remain unchanged after long periods of use. Circuit resistance is said to be high and to minimize contact and lead resistance. Instrument is compensated for effect of ambient temperature on resistance of its moving coil. Scales are made to customer's specifications: r.p.m., f.p.m., m.p.h., etc. For switchboard mounting, instrument is supplied with studs which also carry the current. For wall mounting, case is fastened by rear flanges; wires then connect to binding posts. Magneto is provided with flanged collar for attaching drive gear or sprocket. Its base is 3⅝", overall height 3⅛", maximum width 4⅛". Instrument and magneto are dustproof and splashproof. For extra-heavy duty and higher speeds other magnetos are available upon special order.—*J-B-T Instruments, Inc., 1110 Chapel St., New Haven, Conn.*

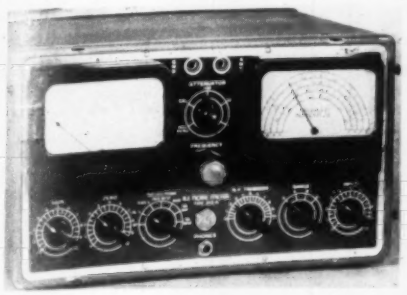
Gage for Checking Fillet Welds

New fillet-weld gage is said to meet need on the part of welding inspectors and operators for a fast, accurate means of checking size of fillet welds on jobs which have

to meet rigid specifications. Pocket-size, it consists of three stainless-steel stampings held together by a bolt and a knurled thumb-nut. Convex, concave or Standard fillets can be checked by fitting edge of gage flush against work so that indicating portion of gage rests on weld bead. It can be used on fillets of following sizes: 3/16", ¼", 5/16", ⅜", 7/16", ½" and ⅝". These sizes are clearly marked in black.—*General Electric Co., Schenectady, N. Y.*

Radio Noise Meter

"Type 312 Radio Noise Meter" was ... in accordance with recommenda... of Joint Committee from Edison Elec... Institute, Radio Mfrs' Ass'n and



NEMA, appointed to study sources of interfering noises and propose basic method of measuring which would aid in their reduction or elimination. New noise meter is for service in field and laboratory. Its principal uses include measuring noise levels of transmission lines, electrical apparatus, and field strength of radio signals in comparison with noise levels. When equipped with a directive loop antenna, it indicates direction of signals and interfering noises. Fundamentally, instrument is a superhet. receiver provided with a small vertical antenna and containing an output metering system which is equipped with an integrating network giving quasi maximum indications on a direct-reading indicator. Instrument employs a self-contained calibrating source. Three types of auxiliary network are available as accessory equipment: for measuring power line noises and electrical disturbances generated by single-phase or two-wire electrical apparatus, and a combination network for measuring three-phase or single-phase a-c. electrical apparatus. Overall dimensions 13⅜" × 13¾" × 9¼".—*ECA Mfg. Co., Camden, N. J.*

Inside Micrometers

New "No. 80 Series" inside micrometers are designed for those mechanics not requiring various features found only in maker's "No. 680" line. Range is obtained by

use of extension rods and collars. "No. 80A" having six rods and a 1½" collar and range from 2" to 8", while "No. 80B" has ten rods and a ½" collar and range from 2" to 12". Both have ½" movement of screw. Provision is made for adjusting tension and taking up wear on the screw. Hardened and ground contact points of rods are adjustable for maintaining individual lengths. —*Lufkin Rule Co., Saginaw, Mich.*

TWELVE COCHRANE FLOW METERS COMPLETE DECADE OF ACCURATE SERVICE
When the Hotel New Yorker was built in 1929, twelve Cochrane Mechanical Flow Meters were selected to measure steam flow, condensate flow and temperature and pressure as well.
10 YEARS AT THE HOTEL NEW YORKER
Mr. Warren D. Lewis, New Yorker's Chief Engineer, says: "We have found the meters very useful in keeping track of our costs, especially the flow meter on the condensate which permits a division between the steam used by the engines and that used for building heating and hot water."
Cochrane Bulletin 209 shows typical installations and contains useful data on flow meter design and operation. Write for a copy.
Electric Flow Meter
COCHRANE CORPORATION • 3120 N. 17th Street, PHILADELPHIA, PA.
COCHRANE
Flow Meters

Large Scale-Model Views of small objects with the B&L Wide Field Stereoscopic Microscope

The Bausch & Lomb Wide Field Stereoscopic Microscope provides enlarged images that to all intents and purposes are equivalent to viewing an actual large scale-model of the object. It bridges the gap between unaided eye imagery and the higher powers of the conventional compound microscope. Its uses are practically unlimited. Special models are available for every type of work.

For complete details write to Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

BAUSCH & LOMB OPTICAL COMPANY

FOR YOUR EYES, INSIST ON BAUSCH & LOMB EYEWEAR, MADE FROM BAUSCH & LOMB GLASS TO BAUSCH & LOMB HIGH STANDARDS OF PRECISION

Save Money with VARI-TYPER

Thousands of business organizations are *saving money* by using the Vari-Typer . . . the composing Type Writer with changeable faces and spaces. This office machine reduces composition and printing costs for statistical forms, brochures, charts, bulletins, catalogs, etc., for either Mimeograph or Offset reproduction. Investigate the tremendous savings possible in your business.

- *WRITE TODAY* for new demonstration portfolio *"How to Profit by Using Vari-Typer"* . . . with actual samples of work produced.

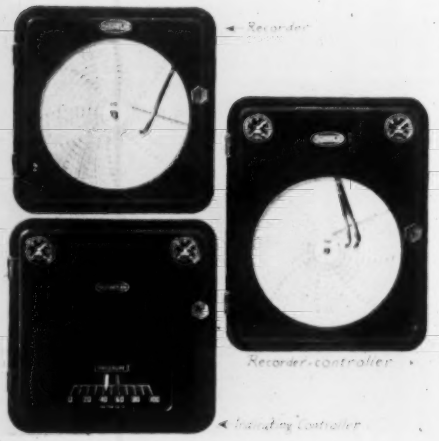
RALPH C. COXHEAD CORPORATION
Manufacturers of Vari-Typer
333 SIXTH AVENUE NEW YORK CITY

INDUSTRIAL INSTRUMENT SERVICE
CLAUD S. GORDON CO., Cleveland—Chicago—Indianapolis

LITTELFUSES for INSTRUMENTS
They lower costs—give superior protection. Cost little. For Instruments, Meters, Radio, Auto, Aircraft. High voltage fuses. Neon testers and indicators. Fuse Mountings. Littelfuses protect! Write for catalog.
LITTELFUSE INC., 4759 Ravenswood Ave., Chicago, Illinois

Re-designed Industrial Instruments

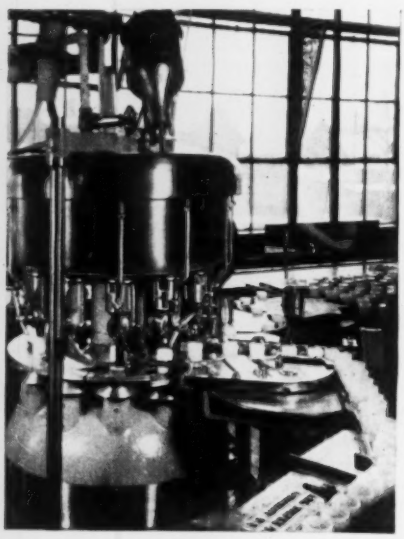
Makers announce new mechanical refinements and restyled cases in their line of indicating, recording and control instruments. Improvements include more com-



pact, faster, amplifying pilot of high capacity; rearrangement of control assemblies so that all working parts including gages may be installed or removed as a unit; die-cast aluminum cases conforming to modern trend in instrument panel layout; new type lock insuring permanently tight door; time set pointer; rigid aluminum chart plate; aeroplane type non-glare gage dials; straight-line high-visibility indicating scale. New instruments retain features introduced by maker five years ago, such as universality of control assemblies; interchangeability of standard parts; adaptability to practically any control application; complete adjustability without disturbing chart record or interrupting the control.—*Mason-Neilan Regulator Co., 1199 Adams St., Boston, Mass.*

Automatic Jar Filler

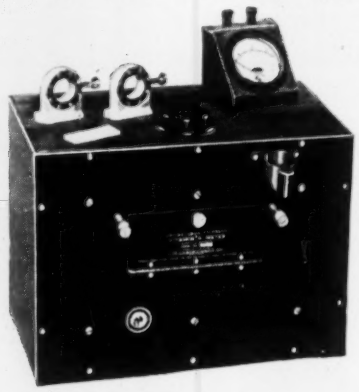
Variations in volume capacity of small size jars cause overfilling or underfilling when volumetric method is used. Therefore, new high-speed "FMC" Special Filler" is of

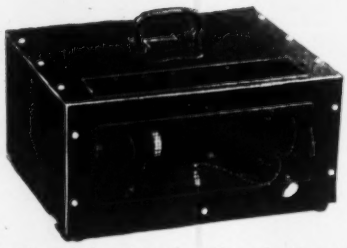


the type which fills all containers to the same predetermined height. Filling nozzle is positioned in center of jar so that each jar is finished with full "crowned" appearance. Jars can be filled extremely close to rim if desired. In filling-control mechanism, twin tubes project down to jar from rotary valve. Material flows into jar through one tube and continues to flow until it reaches level of second tube which is an air-intake tube leading to reservoir chamber. When air tube is closed by material, flow stops "without a single extra drop releasing into the jar."—*Food Machinery Corp., Hoopeston, Ill.*

Instrument for Measuring Vitamin-A Content

Photoelectric measurement of Vitamin A concentration in fish oils is accomplished by "United Drug Company Vitamin A Meter." Its design is based on principle of absorp-



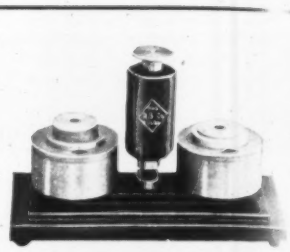


tion of certain wave-lengths of ultra-violet radiation by Vitamin A. This absorption is determined by measuring remaining u-v. radiation directly, "using special photoelectric cells in a special circuit." A single reading on a properly prepared sample usually takes less than five minutes.—*G-M Laboratories, 1733 Belmont Ave., Chicago, Ill.*

Test Oscillator

New "No. 167" test oscillator is an advanced model of maker's earlier No. 153 oscillator (*Instruments*, Aug. 1938, page 192) with addition of an output cable and

a new type pointer. Panel has been completely restyled. No. 167 has high r-f. output (1 volt), fundamental frequency range of 100 to 30,000 kc. and the dial scale is $6\frac{1}{4}$" in diam., 50" long. External frequency modulation may be added for oscillographic method of servicing. Instrument has a 400-cycle output of 8 volts for audio circuit testing. Other features: six bands, minimum signal 2 microvolts, negligible leakage. Weighing $12\frac{1}{2}$ lb., it measures $13\frac{3}{4}$" wide, $9\frac{1}{4}$" high and $6\frac{1}{2}$" deep.—*RCA Mfg. Co., Camden, N. J.*



R. S. DEAD WEIGHT GAUGE

Can be put on a line at any connection where an ordinary gauge is placed. It gives the exact pressure in the line by actual dead weight. The standard gauge is made for pressure intervals of one pound and is supplied with weights and hardwood carrying case in ranges up to 3500 lbs. per sq. in.

Description and Prices Supplied on Request

THE REFINERY SUPPLY CO.
631 E. 4th St. Tulsa, Oklahoma

INTERVAL TIMERS
PROCESS TIMERS
SIGNAL TIMERS
TIME SWITCHES
FLASHERS
Write
AUTOMATIC Electric Manufacturing Co.
Mankato, Minnesota

Three-unit Analyzers

New "Kit Set" comprises three matched instruments, with necessary leads, in a carrying case. Nine different instruments are available, all of them multi-range. Of

these, "No. 280" a-c. ammeter was described in our May 1940 issue, page 121. The others comprise two a-c. voltmeters, one d-c. voltmeter, one d-c. and one a-c. milliammeter, one d-c. ammeter and one d-c. ohmmeter. None weighs more than 20 oz.—*Simpson Electric Co., 5216 West Kinzie St., Chicago, Ill.*

The Electron Microscope

By VLADIMIR K. ZWORYKIN

Director of Electronic Research, RCA Mfg. Co., Camden, N. J.

BEFORE the beginning of the present century it was recognized that the light microscope was fundamentally incapable of resolving objects smaller than about 1,000 A.U., by reason of the relative coarseness of the medium used for observation, namely, light. To increase resolving power it is necessary to use shorter wave-length radiation. Although it has been possible to increase the useful magnification somewhat by the use of ultra-violet light, no great increase in resolving power was attained prior to the advent of the electron microscope, because of the impossibility of making lenses for focusing radiations of shorter wave-length, such as X-rays. The electron microscope, employing high-velocity electrons (effective wave-length about 1/100,000 that of visible light) now makes it possible to resolve objects fifty times smaller than can be seen with a light microscope.

In principle the electron microscope is similar to a compound light microscope, with electrons playing the rôle normally played by light. There is a close analogy between electron paths in a potential field and light rays in a refractive medium. Upon this analogy is based the new science of "electron optics" whereby it is possible to design "electron lenses" in the form of armored coils having suitable pole-pieces, which are capable of forming electron images in the same way that glass lenses form optical images. In the RCA electron microscope, illustrated below, a thermionic cathode serves as an electron source, which is the counterpart of the light source of the light microscope shown diagrammatically at the right. The electrons leaving the cathode are accelerated to high velocities by the 30 to 100 kilovolts applied to the electron gun at the top of the instrument, and are caused to converge upon the specimen under observation by a magnetic electron lens. After transmission through the specimen they pass through another magnetic lens, the microscope objective, which forms an intermediate image of the specimen, magnified about 100×. The electrons from part of this image then go through a third magnetic lens which reforms them into a final image, enlarged 25,000×. This final image is either made visible on a fluorescent screen or recorded on a photographic plate. The image on the photographic plate contains detail which cannot be resolved by the unaided eye, so that in order to obtain the full useful magnification it must be further enlarged, optically. A resolution of about 50 A.U. can be obtained.

The entire electron optical path in this instrument is maintained at a high vacuum in order to permit the unobstructed passage of electrons. Air locks provided at the object and photographic chambers permit changing specimens and photographic plates without admitting air into the main chamber of the microscope. The specimen under observation cannot, of course, be mounted on a conventional glass microscope slide, because such slides are completely opaque to electrons. Instead the object is mounted on a nitrocellulose film about 1/1,000,000 cm. thick, supported on a fine wire mesh.

The electron microscope has already revealed to the biologist many things heretofore unseen, such as viruses, bacterial flagellae, the structure of the smaller micro-organisms, etc. Of course it also finds important applications in industry. It has been usefully employed in the study of the size and shape of colloidal particles which cannot be resolved in the light microscope. Minute particles and fibers are of the utmost importance in rubber, ceramic, paint, textile and other industries. It is impossible to foretell what revolutionary advances in our knowledge can be expected from the application of the electron microscope to all phases of science and technology.

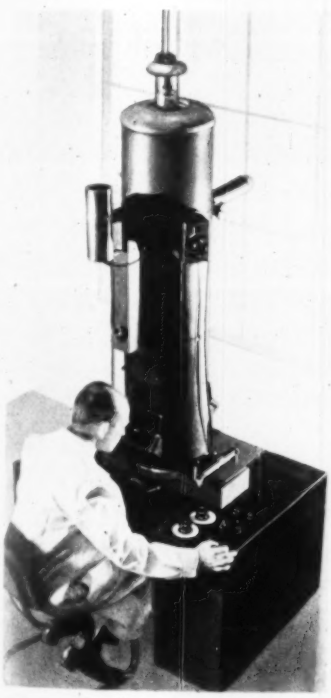
REFERENCES

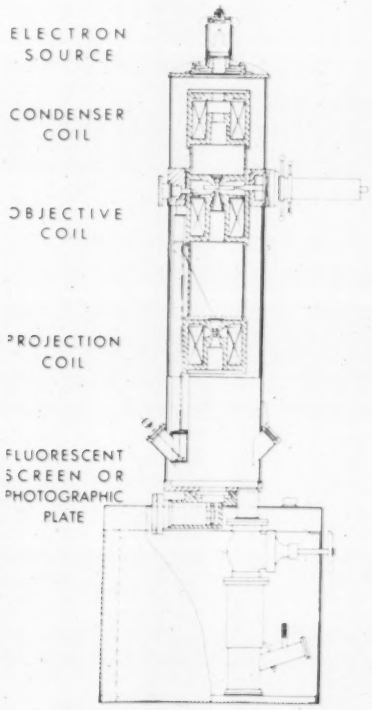
[1] L. Marton, *Bulletin de l'Académie Belge*, Bruxelles, Vol. 21, 1935, page 606.

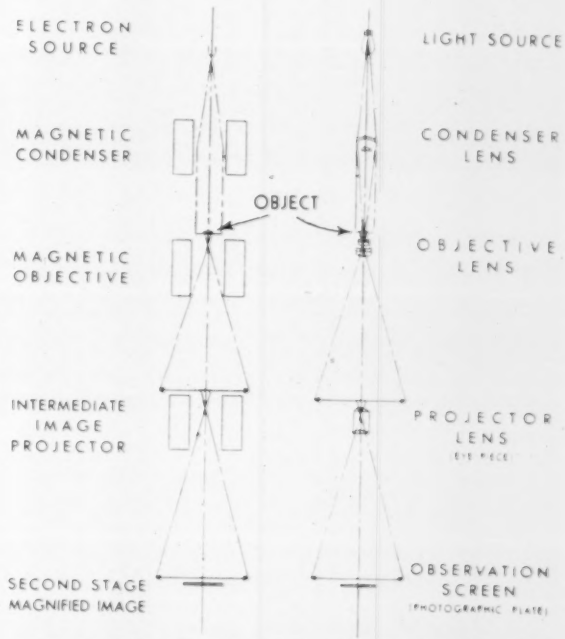
[2] A. Prebus & J. Hillier, Construction of a Magnetic Electron Microscope of High Resolving Power, *Canadian Journal of Research*, Vol. 17, April, 1939, pages 43-63.

[3] B. vonBorries & E. Ruska, Experiments, Calculations and Results in the Resolving Power of the Supermicroscope, *Zeitschrift fur Technische Physik*, Vol. 20, No. 8, Aug. 1939, pages 225-235.

[4] L. Marton, A New Electron Microscope, *Physical Review* (in press).





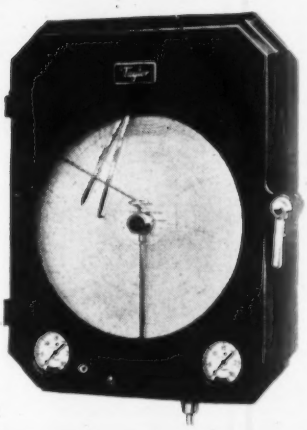


COMPARISON OF OPTICAL SYSTEMS OF ELECTRON AND ORDINARY MICROSCOPES

YOU CAN'T IGNORE PRE-ACT!

The New Taylor Fulscope Controller

It has Pre-Act!



Pre-Act gives still finer control of your processing

IT'S TAYLOR'S— DISTINCTIVELY TAYLOR'S!

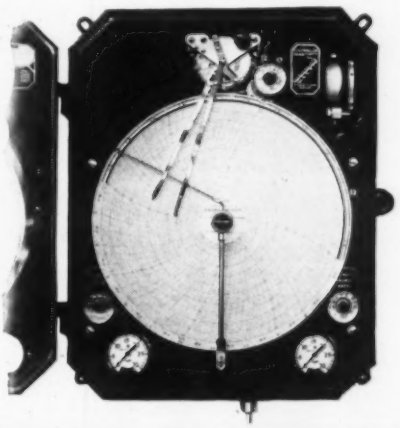
Pre-Act is a new and major control aid for you. It helps you govern those sudden disturbances which may have been upsetting your process control operations.

Pre-Act is the amazing *new* control effect created by Taylor Instrument engineers. It's available only in the great new Taylor Fulscope Controller.

Pre-Act's unique "on guard" action is based on the *rate* of control-point deviation. Here's what happens: there's a sudden control disturbance (either with or without sustained load changes), and it causes wasteful over-peaking or oscillating. Instantly Pre-Act acts—brings about a larger valve action. It smooths out those control kinks.

Pre-Act comes as a standard, fully adjustable unit assembly which may be incorporated in either the Recording or Indicating types of the new Fulscope Controller, originally or when you wish. Coupled with *Adjustable Sensitivity and Automatic Reset*, it makes the Taylor Fulscope Controller the ultimate instrument for profitable process control. Find out just how *you* can save money—by writing Taylor Instrument Companies, Rochester, N. Y. Also Toronto, Can. In Great Britain: Short & Mason, Ltd., London.

5 Forms of Control, including unique Pre-Act, available in the New Taylor Fulscope Controller



Taylor

Indicating | Recording • Controlling

TEMPERATURE, PRESSURE, FLOW *and* LEVEL INSTRUMENTS

This new catalog is modest *but its publication is* **important**

An Important Event

The appearance of this modest catalog means that

the world's most accurate pressure gauges are at last commercially available

The News Behind the News

In the early nineteen-twenties, improvements in the construction of hydraulic type testing machines created a demand for pressure gauges far more accurate and reliable than even the best "test gauges" then on the market. Otto W. Heise undertook to solve the problems involved—and he solved them.

Since 1924, all Southwark-Emery hydraulic testing machines have been equipped with the gauges designed by Otto W. Heise—two or three on each machine, contributing to the outstanding performance of these machines.

Government departments, universities and great industries began placing urgent orders for similar gauges. Arrangements were made for collaboration with the laboratories of the A. H. Emery Co., of Stamford, Conn. Analysis disclosed that nearly 100% of requirements for "specials" could be met by a series of standard sizes, etc.

To serve our new customers, these "standards" were adopted. At the same time, Standards of Quality and Performance were *raised*.

Therefore, in announcing the "commercial availability" of our gauges, we wish it understood that—as in the past—every transaction must and will mean the purchase of a tangible "thing" *plus* a Guarantee of Accuracy and a Certificate of Calibration at 20 points on the final dial.

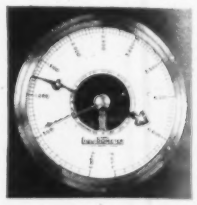
Note. Prices are surprisingly low. Example, $120 for a ten-inch (11¾" O.D.) gauge with 500 graduations.

Informative Catalog Just Out—Send For It

HEISE BOURDON TUBE LABORATORIES
275 NOBLE AVE. BRIDGEPORT, CONN.
In Collaboration with The A. H. Emery Co.

LIQUID
A$$ET$
Controlled

LIQUIDOMETERS provide continuous dependable and accurate knowledge of liquid levels.



LIQUIDOMETER—Remote Reading Gages. Automatically indicate or record liquid levels. No pumps, valves or auxiliary units required to read them. Balanced hydraulic transmission system ingeniously compensated for temperature variations on communicating tubing. Accuracy unaffected by variations in specific gravity. Models are available for remote signals, automatic-control of pumps, etc. Direct reading models available where remote reading is not required.

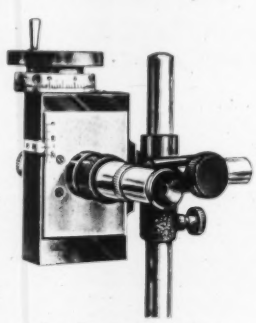
LEVELOMETERS — Dial Type Hydrostatic Gauges operate on hydrostatic principle of establishing balance between head of liquid and an indicator. Dial indication featured. No liquid to expand or contract and create errors. One dial can be arranged to gauge a group of tanks.

Approved by Underwriters Laboratories and similar bodies for gauging hazardous liquids.

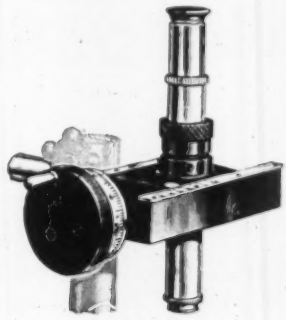
Write for details

THE LIQUIDOMETER CORP.
36-27 SKILLMAN AVE. LONG ISLAND CITY, N. Y.

GAERTNER
MICROMETER SLIDES
provide accurate and convenient horizontal and vertical measurements



As Cathetometer
(vertical motion)



As Comparator
(horizontal motion)

These versatile instruments have wide applicability in laboratory and shop. Fitted with microscope or telescope they serve for accurate linear measurement. Depth measurement is obtained with the microscope mounted parallel to the direction of motion. They may also be used as stages wherever accurate displacements are needed.

Ranges: Up to 4 inches or 100 mm.
Readings: Down to .00005 inch or micron.

The GAERTNER SCIENTIFIC CORP.
1211 WRIGHTWOOD AVENUE • CHICAGO • U. S. A.

Instruments for "Logging" and Sampling Oil and Gas Wells While Drilling

By J. T. HAYWARD and L. M. SWIFT
Vice-pres., Barnsdall Research Corp., Engineering Laboratories Inc.,
Tulsa, Oklahoma

INTRODUCTION

AMONG measurement problems connected with drilling wells for the production of oil or gas are the accurate determinations of (1) the contents of the porous formations encountered in drilling and of (2) the depths of these porous formations below the surface. Since most wells are drilled to locate oil, it is essential to know (3) just when the bit penetrates oil-bearing formations and to determine quickly (4) the relative productivity of such formations. When oil in paying quantities is located in a well it is important also to know (5) the exact location of the top of the oil sand so that the casing may later be landed and cemented at the proper point in order to produce maximum volume of oil with minimum gas-oil ratio.

Wells have been drilled through paying oil formations without the driller or operator having been aware of that fact. In order to eliminate this possibility, it has been customary to take cores and test them for probable oil content. This is a rather difficult and expensive procedure and often does not give as much information as is desirable. Even the new electrical coring method—which gives a better picture of the porous formations drilled through and has greatly reduced expenses—can only be done after the well is drilled; and it does not give the desired information at the time when it would be most important, i.e., at the time that the bit is actually penetrating the gas or oil-bearing formation.

Instruments—more than twenty of them installed in a trailer—are the basis of a radically new method of obtaining data. The "Baroid Well Logging Service," herein described, not only gives accurate data on the content and depth of the sands to be obtained, but gives the operator additional data (never heretofore available) which enable him to drill the well more intelligently and generally at greatly reduced expense. The new method, in time, may possibly eliminate the necessity for taking cores. More than eighty wells have been drilled to date (April 1940) using this instrumental method.

This new method takes advantage of the fact that the oil, gas, or salt water content of any formation drilled up by the bit must of necessity be picked up by the drilling mud as it is circulated during drilling. If, then, any unit volume of the drilling mud, upon returning to the surface, is subjected to the necessary tests and the content of that unit volume is accurately correlated with the depth of the hole *at the time that particular unit volume of mud was passing the bit*, not only is it possible to determine whether or not that particular part of the formation being drilled contains gas, oil, or salt water, but it is possible to determine the relative quantities contained in that particular part of the formation.

Tests are made on the mud returning to the surface to determine the gas, oil, and salt water content thereof. All of the instruments and practically all of the equipment necessary to make these tests, as well as to correlate the samples of mud with the depths from which they are obtained, are mounted in a trailer which can be hauled to and from the well by a passenger automobile. Fig. 1* shows the instrument board as at present installed across the rear of the trailer. In front of the board is a table on which the operator works. On the small panel at the left is a telephone connected to a similar telephone mounted beside the driller. (These are of a special type allowing easy communication in spite of the noise around a drawworks.) On the same panel are controls for signaling, etc.

*Front-cover photograph—EDITOR

POWER CONTROL

In describing the instrument board, it may be well to start with the "power instrumentation" and then discuss the various items of "logging instrumentation."

The upper portion of the central panel is occupied by the power and meter sub-panels, which include d-c. and a-c. voltmeters and ammeters—four altogether. A 200-foot cable, carried on a reel outside the trailer, can be plugged into any convenient outlet on the rig's system. For use at rigs having direct current a 750-watt converter is mounted in the trailer and the 110-volt 60-cycle output from this is used on the a-c.-operated instruments. For use where the rig supply is a.c., a rectifier supplies such d.c. as is required. A Variac, mounted on the sub-panel just below the ammeters and voltmeters, allows the a-c. voltage to be maintained at a reasonably constant value. Two overload circuit breakers, one each for a.c. and d.c., are supplied, one of which is specially fitted to trip in case of a voltage higher than that for which it is set by the left-hand knob on the power sub-panel.

GAS DETECTION

The first major piece of apparatus is the gas-detecting instrumentation. This occupies the upper portion of the left-hand panel. A motor-driven vacuum pump, mounted behind the panel, draws air from a special trap mounted on the mud flow line through a filter, a dehumidifier, a meter, and finally a hot-wire type gas detector. If desired, a full-scale reading can be obtained with as little as one cubic inch of gas per hour. The gas detector device includes several novel features which make possible this extreme sensitivity and without which it would be impossible to employ the device for logging purposes. It also includes an alarm which rings a bell to warn the operator when a gas show occurs.

With the sensitivity of the instrument set to maximum, it will give a reading when 0.25% of gas is present in the stream; and it has been found that these indications can be obtained fifteen or twenty feet before the bit actually reaches the oil or gas formation. (This is probably the only logging system that can pick up evidence of an oil or gas sand before it is actually reached.)

With any given gas sand and setting of the instrument, the readings depend upon the rate at which the sand or other porous formation is being drilled and upon the diameter of the hole. The readings are not influenced by the rate of circulation, since the mud merely acts as a transportation system to bring the gas to the surface. Therefore, when plotting the logs, the values are obtained by multiplying the instrument readings by a factor depending upon the rate of drilling and the diameter of the hole. This is most important for satisfactory results and has brought to light several interesting facts.*

OIL DETECTION

The next major piece of apparatus is a means for detecting oil in the mud. For this purpose ultraviolet radiation provides a sensitive method: a pint of oil poured into the

*In a certain field it has been found that the hard shell immediately overlying the oil sand contains gas at high pressure. This gas had not been known previously because, owing to the slow rate at which the cap was drilled, it was not noticeable in the mud. Using this logging method with the correction factor, it was easily detected and its presence was subsequently confirmed in the following practical manner: the wells in this area usually had their casing set on top of the shell and had suffered from high gas-oil ratios; but when, after the finding of gas in the cap by this logging method, casing was set in the bottom of the shell, the high gas-oil ratio troubles disappeared.

pump suction can easily be picked up at the flow line after circulation through the well, and small sands of a couple of feet in thickness are picked up without difficulty. The apparatus incorporates facilities for flooding the sample with visible light on top of the ultraviolet. The oil in the samples appears as small, bright specks under the ultraviolet. By observing a fluorescent spot through the magnifying glass and then switching on the source of visible light, it is possible to distinguish crude oil from other oils that may accidentally get into the mud. It is surprising but fortunate that crude oil from a previous show that already has been around the system once or more is distinguishable from a new show: the new oil fluoresces more brightly than that which has been circulating—possibly due to the mud bleaching the fluorescent component.

The samples for the ultraviolet type detector are obtained from a sampler which collects an *average* sample of the mud passing the bit between predetermined depths. Reason: most drillers feed the bit down in jerks of an inch or two at a time, so that intermittent samples vary greatly in oil content and may be misleading. A correction factor is used, which depends upon the rate of drilling, the diameter of the hole, and the rate of mud circulation. It is intended later to supply equipment which will pump a representative sample of the mud stream through apparatus in the trailer, where it can be observed continuously.

SALT WATER MEASUREMENT

The instrument for logging salt water is located at the bottom of the central panel. In order to detect salt water, it is necessary to compare the ingoing mud with the outgoing mud because water and chemicals are added in the pits; and the mud is not, therefore, returned to the hole in the same condition as it came out. (This comparison is not usually necessary for the oil and gas determinations.) The method consists of placing electrodes in the ingoing and outgoing mud and comparing the resistances, making proper allowance for the time taken for any increment of the mud stream to traverse the subsurface circulating system. This problem is complicated by the temperature coefficient of resistivity of the mud. Therefore, the resistance-measuring bridge automatically corrects the readings for temperature variations. Moreover, unless special steps are taken, the electrodes cake with mud and give incorrect readings. All these difficulties have been overcome, however.

DEPTH AND DRILLING RATE MEASUREMENTS

The two-counter instrument shown at the lower half of the left-hand panel is a depth indicator on which the depth of the well is shown at all times. One counter shows the total depth of the well itself at all times, the other shows the distance, if any, that the bit is off bottom. A special circuit allows the depth indicator to account automatically for each additional length of pipe inserted in the string.

The instrument below the power panel on the central panel is the pump stroke counter and rate meter. The counter at the lower right-hand side counts the number of strokes made by the pump, while the large indicator in the middle shows the rate at which the pump is running in complete cycles per minute. A lead runs from the instrument to switches mounted on the pumps. The function of this instrument is to measure the quantity of mud circulated so that the findings of the other instruments can be related to the depths to which they apply; taking into account the lag between the time the mud sample passes the bit and the time it reaches the surface and is analyzed.

The operations carried out in the trailer are concerned with the fluid phase of the mud, and there is no relative slip between the different fluids during the journey up the hole as there is between solids and the mud carrying them to the surface. It has been found also that there is little longitudinal mixing during the journey up the hole; and that when, for instance, an oil sand is drilled, oil suddenly appears in the returns and as suddenly disappears when the sand is passed. The proper functioning of the instrument depends upon the fact that the volume of mud handled by the pump per stroke is remarkably constant with the type of pumps used at rotary rigs there is practically no slip. When it is considered, this is not surprising, because, owing to the type of fluid pumped, as soon as any leakage or slip commences in the pump, the part concerned is rapidly cut out and the pump put out of action. This does not mean that the pumps have a 100% volumetric efficiency calculated on their bore and stroke, because generally they seldom make their full-rated stroke; but it does mean that once found, the volume pumped per stroke remains constant and the pump can be used as a mud meter.

On the lower left hand side of this instrument is a counter arranged to run in step with the main counter but in such a manner that while running in step, it will keep a predetermined number of strokes ahead of the main counter. This saves the operator a great deal of calculation: he notes the depth of the well from the depth recorder which is, say, 6,000 feet. He also notes the reading on the second counter which is, say, 500, and enters it alongside 6,000 feet on the special form provided. He repeats this operation again when the depth shows to be 6,001 feet and finds, say, 1500 on the second counter. Since the second counter leads the main counter by the number of strokes required to bring the sample to the surface, he knows that the sample relating to the drilling between 6,000 and 6,001 feet will be arriving at the surface while the main counter reads from 500 to 1500. A switch on the second counter allows its leads over the main instrument to be increased continually as the depth of the hole increases.

Accurate logging is dependent upon this instrument, as any attempt to use time as the basis for figuring lag between cutting the sample and its arrival at the surface leads to difficulties in practice, owing to the fact that the rig may be shut down to change joints, etc., while the sample is on its way. Moreover, attempts to use time are complicated and conducive to error.

Experience with this combination pump stroke counter and rate meter has shown that it has other uses not directly connected with logging. For instance, it was found to give almost infallible warning of washouts. When a washout starts, the pump rate commences to increase and continues to increase slowly, until failure of the pipe occurs. This usually takes several hours. This speeding up is almost imperceptible to the driller but is easily noted on the meter because, in addition to the pointer on the large indicator, there is a hand that can be set to normal pump speed a few minutes after the pump has been started and settled down to its speed.

Speed changes due to variations in boiler pressures are easily distinguished from those due to an incipient washout because changes due to boiler pressure are up and down and of small amplitude, while the change due to a washout is a steady increase.

It has also been found by using this instrument that when the readings are slow—that is to say, when more than the calculated number of strokes are being taken to bring the sample to the top—the walling properties of the mud are poor and caves are being washed in the walls of the hole. Attention to the mud usually rectifies the situation. When, on the other hand, the readings are fast, it indicates that circulation is too slow or that the mud is not sufficiently thick to carry the cuttings to the surface, which condition, unless rectified, is generally followed by stuck drill pipe.

MULTI-PURPOSE RECORDER

The right-hand panel is occupied by the "Sclerograph" or drilling rate indicator and associated multiple-function recorder. The corrected drilling rate is recorded on a chart which is driven in synchronism with the depth indicator proportionally to the distance drilled. The rate is also indicated at the top of the panel, for quick reference. Since the rate of drilling varies more or less with the hardness of the formations penetrated, this recorder automatically draws a log which corresponds somewhat to the porosity curve on an electrical log.

In addition to the drilling rate, the Sclerograph records on the same chart the torque required to drive the drill. This log helps to interpret the curve of the drilling rate. A third curve recorded corresponds to the gas detector indications. This curve shows the magnitude of any gas show which occurs, against the depth of the well at the time of its occurrence. Since this depth may not be the depth from which the gas show originates, it become necessary to record, as well, the pump stroke count. This count is so recorded that

Continued on page 160

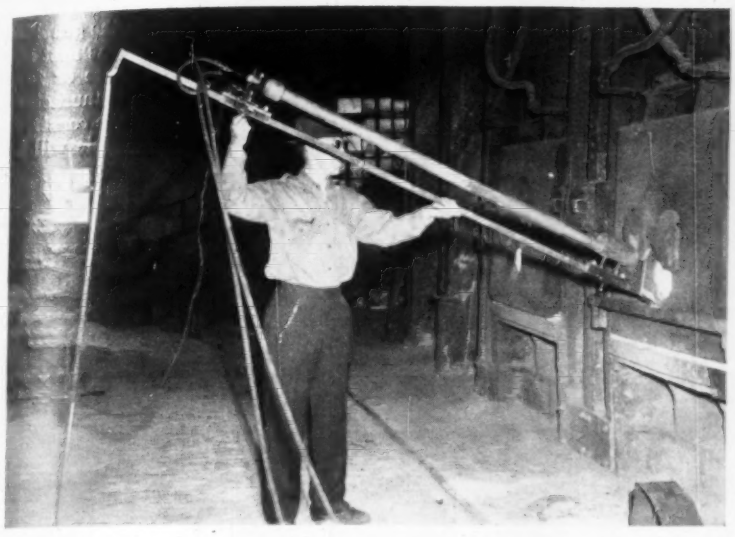


Fig. 1. Portable thermoelectric pyrometer employing C-SiC thermocouple. Telescoping stand whereby the thermocouple proper slides down into the liquid-steel bath. The furnace illustrated here is a 40-ton acid open-hearth furnace. The instrument suspended at the left is a portable potentiometer especially developed for use with the C-SiC couple. Its construction prevents temperature gradients within it.

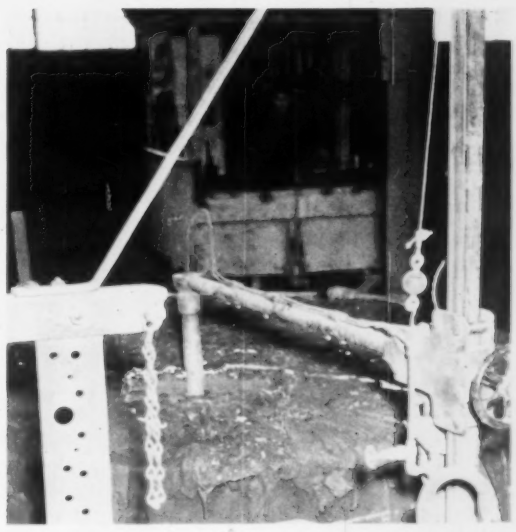


Fig. 2. Thermocouple for use in large ladles (more than 20 tons). The supporting mast is fixed to the floor. By means of a pulley and counterweight the thermocouple proper is lowered into the ladles as they pass on their way from the furnace to the pouring platforms.

Pyrometry of Liquid Steels and Pig Irons*

By G. R. FITTERER
Head Metallurgical Engineering Department, University of Pittsburgh

INTRODUCTION

TWENTY years ago, at the symposium on temperature measurement held by the American Institute of Mining and Metallurgical Engineers, the Dean of Pyrometry of that time, Dr. George K. Burgess, stated[1] with reference to the measurement of liquid steel temperatures: "Previous investigations have shown some of the difficulties to be overcome: mechanical, metallurgical and thermal in nature. The pyrometer itself is the least of these. The greatest is a refractory that has the requisite mechanical, chemical and thermal properties; it must be robust enough, when hot and cold, to withstand abuse; it must withstand the corrosive action of basic and acid slags, flames, hot gases and liquid steel; be non-porous and not give off fumes or water vapor when heated; it must not crack on sudden heating or cooling and must be able to withstand a temperature of nearly 1700°C.; and finally it must be capable of being manufactured into closed tubes of convenient size with a thickness of wall that is not too great, nor of too low thermal conductivity, to allow the interior to assume rapidly the temperature of the region into which it is thrust."

Dr. Burgess thus aptly stated the problem of temperature measurement whether the method be optical or thermoelectric. He went on to recommend tentatively the use of graphite tips which might be immersed in liquid steel so that optical pyrometer readings could be taken on their exterior surface immediately after their removal from the furnace. Also, a hollow graphite tip could be used and the optical pyrometer sighted down to the closed end of the tube during its immersion in liquid steel. He recognized and pointed out several defects in both of these methods.

The problem of liquid steel temperature measurement may still be divided into mechanical, metallurgical and thermal aspects. A fourth aspect, which was not mentioned by Dr. Burgess, may be termed the practical aspect. It is that the measurement must fit in and not interfere with, ordinary plant routine.

This practical aspect of the problem is the one which has been found most impeditive by the active workers in this field, who have been striving to overcome the mechanical, metallurgical and thermal difficulties. Operators in the mills are concerned primarily with production and delivery. They will stand for no interference with their operations, regardless of what claims are made for the accuracy and general scientific utility of an apparatus. An instrument to be accepted by the liquid iron and steel industries must not only be of acknowledged accuracy but must be so constructed that the least possible number of man-hours (or man-minutes) is required for its operation. In many plants it must operate *continuously* with little attention. Installation and maintenance costs must be low.

Moreover, no pyrometer of any sort will ever be successful in the liquid iron and steel applications unless it reveals sufficient metallurgical information to show the operators why they should use it for control purposes. No instrument is ever going to be accepted until it reduces some of the "mysteries" in the art of steel making to a science. The development of the platinrhodium-platinum thermocouple by Le Chatelier reduced the mysteries in the art of heat-treatment to a science—a science of many ramifications, as it is today. This is exactly what is needed in the liquid iron and steel industries. The useful qualitative information that we now have must be placed on a quantitative basis through the use of measuring instruments. Formerly, the few instruments used in the melting shops were not taken seriously and their results were used only as a guide by the melter. If the instrument showed an abnormally low or high temperature, the melter disregarded the reading entirely and tapped the heat on his own judgment. And he was not to blame when—as was the case until recent years—his "guesstimate" of temperature was more reliable than the readings of unsuitable instruments. By unsuitable instruments are meant chiefly those which operators opposed on practical grounds (interference with plant routine as explained above) and also the following categories:

1. Instruments inherently unsuitable because their primary measuring elements wore out too quickly when exposed to liquid metal and slag. (Examples, rare-metal cou-

*Presented before the Symposium on "Temperature, its Measurement and Control in Science and Industry," American Institute of Physics, New York City, Nov. 2-4, 1939.

[1] A.I.M.M.E. Symposium on Pyrometry, American Institute of Mining and Metallurgical Engineers, New York, 1920, Page 6.

ples in various combinations of inner and outer "protecting" tubes which had to be renewed so frequently that the cost in man-hours was prohibitive—in addition to the "interference" objection.)

2. Instruments inherently unsuitable because of the too-early occurrence of sources of error invisible to the eye of the operator. (Example, the rapid contamination of thermo-

Fig. 3. Sectional view of C-SiC thermocouple assembly. 1—Silicon carbide rod. 2—graphite tip. 3—graphite sleeve. 4—Graphite main section. 5—Graphite head nipple. 6—Fused silica insulator ($1\frac{3}{8}$" × $1\frac{1}{8}$" × 8"). 7—Fused silica insulators (2⅝" × ⅝" × 5"). 8—Porcelain insulator. 9—Copper cooling coil for SiC. 10—Copper cooling coil for graphite.

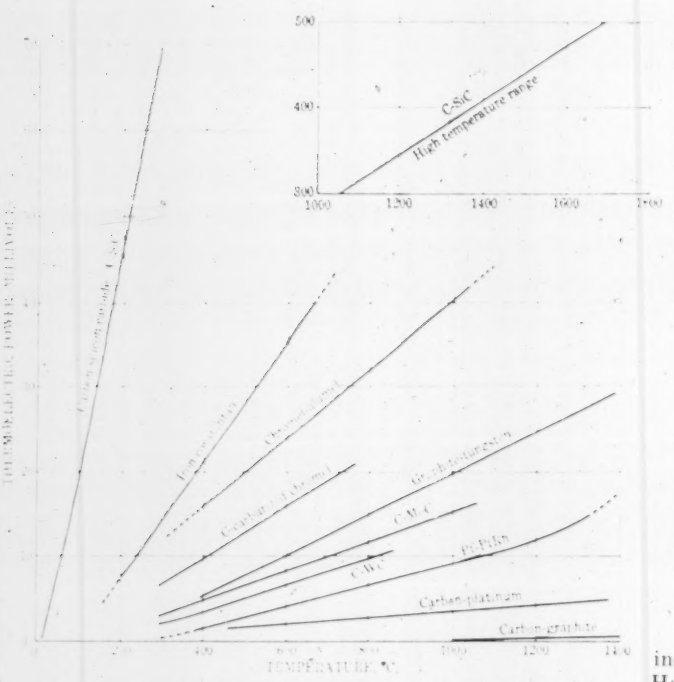


Fig. 4. Comparison of temperature-emf. relation of C-SiC thermocouple with those of other industrially useful thermocouples. (Courtesy A.I.M.E.)

elements by gases passing through protecting tubes from the start or—at best—long before the tubes showed visible signs of becoming unsuitable.)

3. Instruments theoretically suitable for measuring liquid iron and steel temperatures (some of them successful in the laboratory) but in practice unsuitable because they became "instruments of torture" in actual use in proximity to emergent streams of liquid metal or to melting furnaces, large ladles, etc. (This has been an important obstacle to the accumulation of metallurgically-useful data, such as temperature-*time* curves and other data requiring periods of observation too long for human endurance.)

4. Instruments theoretically suitable but too delicate, too complicated, etc. (Even where the electrical or electronic "instrument end" of the system met no objection, any system with a relatively fragile assembly in contact with molten metal and slag was obviously unsuitable.)

The melter was not to blame then for mistrusting instruments; and quantitative data were unobtainable without instruments. But all this is changing by reason of the successful development of thermoelectric pyrometers which comply with all requirements outlined above. In all these new pyrometric systems the primary element is the graphite *vs.* silicon carbide type of thermocouple which was first announced[2] in 1933 and which in the ensuing three or four years was satisfactorily developed for uniform manufacture and practical use. (No detailed description of the construction and characteristics of the C-SiC thermocouple will be

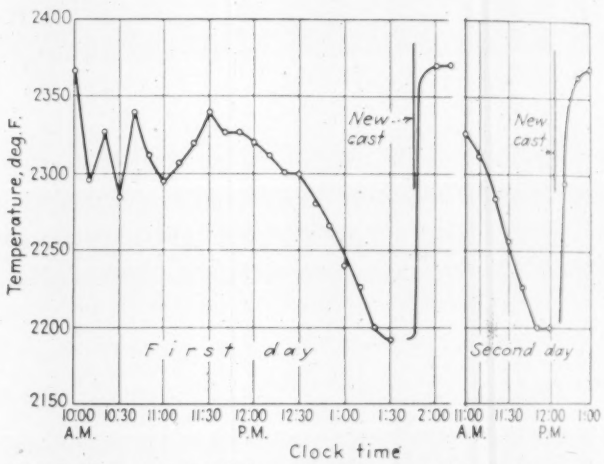


Fig. 5. Temperature variations in a Bessemer mixer (a furnace in which liquid pig iron is held before being taken to the Bessemer converter in transfer ladles). Formerly, the mixer furnace was considered to be simply a retaining vessel having no effect on the iron because of the large masses involved. Adoption of the C-SiC pyrometer made it possible to record unsuspected variations in temperature. Study of such records disclosed previously-unknown reasons for non-uniformity in certain Bessemer steels. (Courtesy A.I.M.E.)

included because they have been described elsewhere.[2,3,4] However, for those unfamiliar with it, Figs. 1 and 2 are installation photographs showing the general appearance of its practical embodiments, Fig. 3 is a sectional drawing showing a typical assembly and Fig. 4 compares the temperature-emf. characteristic of the C-SiC couple with those of others.)

In the last five years, quantitative data obtained through the use of the C-SiC thermocouple have revealed a fast-growing amount of metallurgical information, of which the following is an incomplete list:

1. The solubility of carbon in certain types of pig iron.[5]
2. The effect of the above on the surface quality of large castings such as ingot molds.[6]
3. Cooling characteristics of 100-ton "submarine" or car type ladles transporting liquid pig iron.[7]
4. Temperature variations in a 1000-ton Bessemer mixer (see Fig. 5) and the probable cause for certain variations in blowing such iron in the converter.[8]
5. The determination of the critical freezing range of a great variety of liquid steels.[9]
6. The development of the principle of "Temperature Head" and the application of this principle in the teeming of steel ingots.[10]
7. The effect of temperature on the rate of carbon elimination in the acid open hearth furnace.[11]

[2] G. R. Fitterer. A New Thermocouple for the Determination of Temperatures up to at least 1800°C. *A.I.M.E. Transactions*, Vol. 105, 1933, pages 290-301.

[3] G. R. Fitterer. Some Metallurgical Applications of the C-SiC Thermocouple. *A.I.M.E. Transactions*, Vol. 120, 1936, pages 189-216.

[4] Anon. Fitterer Pyrometer for Measuring Liquid Steel Temperatures. *The Iron Age*, Vol. 140, July 22, 1937, pages 38-40.

[5] *A.I.M.M.E. Open Hearth Proceedings*, 1936, page 139.

[6] *A.I.M.M.E. Open Hearth Proceedings*, 1936, page 141.

[7] *A.I.M.M.E. Open Hearth Proceedings*, 1936, page 138.

[8] *A.I.M.M.E. Open Hearth Proceedings*, 1936, page 135.

[9] *A.I.M.M.E. Open Hearth Proceedings*, 1938, page 40.

[10] *A.I.M.M.E. Open Hearth Proceedings*, 1938, page 40.

[11] *A.I.M.M.E. Open Hearth Proceedings*, 1938, pages 37-42.

LIQUID STEEL

An attempt will be made to answer the challenge stated by Dr. Burgess by describing and discussing the service record of one of the steel ladle C-SiC thermocouples which has been in constant operation since June 1936.

This unit (Fig. 2) has been used in the determination of temperatures in the ladle of an acid open hearth shop, for more than 2000 heats, since its installation. It may be seen from the figure that the couple is suspended on a long horizontal water-cooled arm and that it can be moved both horizontally and vertically. It can be swung around over the ladle and pushed down through 10" to 12" of liquid slag and into some 8" to 10" of liquid steel.

A ladle thermocouple has to be of rugged construction to withstand abuse in production. This unit is inserted by the pit men and the indicating potentiometer is operated by the first helpers. The pit men service the thermocouple by maintaining the refractory wash.

The thermocouple has a replaceable graphite tip 15" long and 1¾" in diameter. After this has worn down to about 1⅜" in diameter it is taken out of service.

In the application under consideration the tip is usually taken out of service after 60 to 70 heats, although in one case a tip lasted for a total of 162 heats. Throughout the three-year service the average tip life in this unit has been approximately 60 heats. As explained in previous articles[2, 3, 4] the life of a tip depends upon the particular service required. Refractory washes are supplied with the couple and their composition depends upon the application. In some new applications the life of the tip is much less than that mentioned above but after a little development work the originally-supplied composition is changed and the tip life is increased.

No breakage due to thermal shock has ever occurred in any installation since the original development of the C-SiC thermocouple. The tip may be plunged cold into steel well above 3000°F., without breakage of any part of the unit.

Readings in the unit being described require about three minutes, since the thermal conductivities of both silicon carbide and graphite are high. Preheating is desirable, so as to not hold up the ladle longer than this period, in case of a "cold heat." In this plant, the length of ladle holding time is determined by the measured temperatures.

The time required (from room temperature) for the measuring junction of the SiC-C thermocouple to reach the temperature of the liquid steel in which it is immersed is not longer than that required by the protected thermocouples commonly used in high-temperature service. It is actually less than that required by thermocouples with double or triple protection. One of the reasons for the speed of operation of the C-SiC thermocouple is that the graphite tube itself is one of the thermoelements. (See Fig. 3.)

No change in the calibration of C-SiC thermocouples has ever been encountered, even after long use at high temperatures. Several units have been recalibrated after as many as 100 immersions in liquid steel without any noticeable change. In one laboratory experiment, for a period of two weeks a thermocouple was heated twice daily to 3600°F. and held at that temperature for one hour each time. Recalibration after this two-week treatment showed no change.

Resuming now the discussion of the practical ladle unit: The life record of one silicon carbide thermoelement is shown in Fig. 6. This SiC rod was used in the measurement of 185 forty-ton heats of steel or a total of 7400 tons. Each point represents the temperature of a forty-ton ladle of steel. The points are arranged in chronological order. It may be seen that there is no gradual increase or decrease in the temperatures with the length of service, as would be expected if the thermocouple had changed its calibration during use. The temperatures ranged between 2800 and 2900°F. both at the beginning of the run and at the end, with an occasional heat above or below this range. No adjustments were made to the potentiometer other than for cold-junction corrections when necessary. These 185 points were taken from the furnace log book of the plant in which this unit is installed.

The fluctuations seem to be quite regular and probably represent heats melted by different furnace operators. Some operators regularly work their furnace hotter than do others, as many companies have found out.

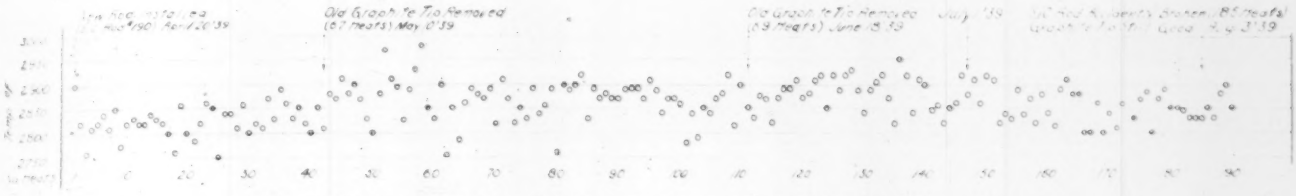


Fig. 6. The life record of one SiC thermoelement. See text of article for interpretation.

According to the company records, these 185 heats of steel, whose temperatures were measured by this one SiC rod, varied considerably in analysis. Most of them were medium-carbon, low-alloy steels and they are listed below together with their various grades, their carbon contents and their "apparent freezing points" which were determined by the method discussed previously[5]:

Number of Heats	Steel Grade S.A.E. Number	Carbon Content Percent	Apparent Freezing Point Degrees Fahrenheit
34	1060	0.20-0.60	2700-2760
20	2300	0.30-0.50	2660-2720
4	3100	0.40-0.50	2670-2710
41	3100	0.14-0.60	2700-2760
56	4300	0.40-0.60	2670-2720
4	4600	0.20	2700
26	6100	0.40-0.50	2620-2690

Depends on carbon content

This information is given to indicate the variety of steels into which the unit was inserted during the life of only one SiC rod.

The parts used during the life of this SiC rod were the rod itself, and three tips. This would indicate an operating expenditure of about 0.4 cents per gross ton of steel. Over a period of three years, however, the operating expenses of this thermocouple has been under 0.2 cents per ton and by paying off the initial cost over a three-year period the total expense has been less than 0.3 cents per ton.

LIQUID PIG IRON

Pig iron for open-hearth furnaces is tapped from the blast furnace into a runner or trough, down which it flows to ladles, which transport it to the mixer furnaces. The mixer is a large holding vessel which may contain from a few hundred to a few thousand tons of liquid iron at a time depending upon the demand in the particular plant. The furnace is only heated slightly so as to keep the refractories in the upper part of the furnace hot. No attempt is made to heat the pig iron to any particular temperature.

Whenever an open hearth requires pig iron, a small ladle is taken from the mixer. Before the introduction of the C-SiC couple, no data were available concerning the variations in temperature of this iron from the time it leaves the blast furnace until it enters the open hearth furnace.

Some operators have always maintained that the temperature of the liquid pig iron has a decided effect upon the quality of the resultant steel. This point was discussed at great length at the joint meeting of the blast furnace and open hearth operators last spring.[12]

That the carbon content of pig iron changes rapidly with temperature is evident from the iron-carbon phase diagram. Also other elements, particularly sulphur, silicon and manganese are known to change considerably in pig iron de-

[12] *A.I.M.E. Open Hearth Proceedings*, 1939, page 204.

pending upon the temperature. This point was also discussed at length at the 1939 joint meeting.

One of the first steps in the study of these composition changes with temperature was taken by one of the larger steel companies about one year ago. They installed a C-SiC thermocouple for taking temperatures of the pig iron as it leaves the blast furnace. The thermocouple tip is inserted in the liquid metal about ten feet from the tap hole of the furnace where there is a deep well in the trough or runner. The C-SiC thermocouple assembly is 22 feet long and is suspended over the point of insertion. When the runner has filled up with liquid metal just after the furnace has been tapped, the thermocouple is lowered into the liquid iron to a depth of as much as 12". The depth of metal at this point is about 18" and if the thermocouple is lowered much below this point the temperature will be lower because of the cooling effect of the refractory runner. Also if the couple is inserted to only a few inches, a slightly lower temperature will be indicated because of radiation losses.

At the instant that the tip of the thermocouple touches the liquid metal, a limit switch starts the potentiometer recorder. Less than two minutes after immersion the thermocouple attains the temperature of the metal. Usually the metal runs from the furnace for half an hour or 45 minutes and the thermocouple is left in the bath until about the last five minutes of the cast. When it is removed, the limit switch again disconnects the operating current of the potentiometer and the thermocouple is again ready for use, except for inspecting the condition of the tip and, possibly, brushing with a refractory wash.

One of the chief advantages of this unit is of course the fact that no special operators are required. Furnace helpers can raise and lower the couple and the temperatures are recorded automatically.

A number of interesting data—of practical value—have been determined through the use of this unit. One of these is that tap-hole difficulties are recorded. If the stream is small, due to a clogged tap hole, the runner refractories will chill the metal and the length of the cast will be increased as will be the time of recorded temperatures. This may be contrasted with a cast which has a full run, in which case the temperatures are high for the shorter period.

It is understood from the men close to this installation that the temperatures being recorded can be correlated with the analysis of the metal, particularly with respect to silicon and sulphur.

The life of the tips in this installation has been increased so that as many as 37 casts have been obtained with one tip. At an average of 30 minutes per cast this amounts to about 18 hours of service. Also this installation is not preheated prior to immersion and this is an indication of the ability of this unit to withstand thermal shock.

Over a seven-month period, the expense of operating this unit has been less than 0.25 cent per ton and by paying off the original installation cost in one year and including the maintenance, the cost of operating this unit is about 0.75 cent per ton.

REPRODUCIBILITY

The above has been a discussion dealing with some of the more practical aspects of the C-SiC thermocouple. There are other matters which should also be discussed, one of which is the reproducibility of the thermoelements. This topic has only received brief mentions in previous articles on the C-SiC couple; therefore an attempt will be made to treat it adequately here.

Under present operating conditions the *graphite elements* of the thermocouple are extruded to size and shape, after which they are thoroughly graphitized. In this condition, the graphite is reproducible within small limits of error, i.e., 0.001% in terms of emf.

Until recently the *silicon carbide elements* were ordered under broad specifications. All rods were calibrated and if they did not fall within the desired limits they were not used as thermoelements. Recently, however, it has been found that rods of desired calibrations may be obtained on the basis of resistivity which in turn is a function of their manufacturing procedure.

Rods are now being obtained which are more nearly within the desired range and are therefore, reproducible. As previously stated, the thermoelectric power of the C-SiC thermocouple is extremely high, being of the order of 300 microvolts per degree Centrigrade. (About half a volt at ladle or bath temperatures.) It will be recalled also that the relation between temperature and electromotive force is linear:

$$T°\text{F.} = dT/dE \text{ (millivolts)} + C$$

or,

$$T°\text{F.} = 6.00 \text{ (mv.)} + 50 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

More than 350 thermocouples have been calibrated to date and about 80% have held within 1% of this formula. By specifying on the basis of resistivity as mentioned above, it is expected that more than 95% will fall within the desired ±1%.

The thermocouples may depart from the above formula in two ways. Either the value of dT/dE may differ from 6.00, or the value of C may differ from 50.

All potentiometers used with this thermocouple now have a slide-wire calibration corresponding to the above formula and are furnished with an auxiliary resistance coil at the base of the slide wire so as to raise or lower the setting of the slide wire at will. The auxiliary resistance is graduated and the user is furnished with the proper setting for every thermoelement.

In the case mentioned above where the value of C is greater or less than 50, a simple adjustment of this coil will adjust the potentiometer to the calibration of the thermocouple. This adjustment rarely involves a change of more than 2 or 3 millivolts or 12 to 18 degrees.

Whenever the slope of the calibration curve is different, however, another procedure is followed. Let us assume that the thermocouple has an extremely bad slope, 6.06 instead of 6.00, and that the application involves the use of the thermocouple at an average temperature of 2750°F. At this temperature the "perfect" couple would indicate 450 millivolts whereas this couple would indicate (2750 — 50) 6.06 or 445.54 millivolts. On the other hand at 450 millivolts according to the potentiometer this couple should indicate 2777°F. By adjusting the auxiliary rheostat this couple can be made to conform to the potentiometer chart or 2750 F. This is the same as correcting the formula for this thermocouple as follows:

$$T°\text{F.} = 6.06 \text{ (mv.)} + (50 - 27) \quad . \quad . \quad . \quad (2)$$

Hence at 450 millivolts this thermocouple will be made to conform with the indication of the potentiometer or 2750 F. Admittedly this is the only point at which the two curves agree exactly, but let us see what difference this makes at higher and lower temperatures.

At 400 millivolts the standard or "perfect" couple will indicate 2450°F. according to equation (1) whereas the corrected equation (2) of the thermocouple in question will indicate 2447°F. Also at 500 millivolts the desired couple will indicate 3050 F. and the one in question will show 3053 F.

Inasmuch as the range between 2450 and 3050 F. covers the steel making range, the potentiometers used in this work cover a limited range also; consequently by this means even thermocouples which have a slope different from that desired can be made to conform with the recorders or indicators within the limits of error just reviewed.

Another point which might be mentioned with reference to reproducibility is brought out in Fig. 6. The last five points on the curve have reference to the new SiC rod that was installed after the old one had been broken and replaced. It can be seen that the new rod continued on recording the same range of temperatures as the one which was taken out of service.

APPENDIX

Note on the Properties of the SiC supplied for the Rods employed in Fitterer Thermocouples

Thermal Conductivity

150°C.	0.0032	g. cal. °C. cm.
1200°C.	0.027	do.

Resistivity

Room temperature	0.54	ohm cm.
760°C.	0.0936	do.
1500°C.	0.36	do.

Wanted—A Broader View of Industrial Plant Instrumentation

By WILLIAM H. SAYLER
Registered Professional Engineer; Manager and Partner, Specialty Sales Co., Salt Lake City, Utah.

In general, the instrumentation of an individual plant has "just growed," like Topsy, and is not usually coördinated with its own different phases, or with the manufacturing process. This probably is the case because few ever thought of doing it any other way.

For many years emphasis has been laid on the value to executives of having records, so that they would know what had happened. Valuable though this information might be, yet it did not serve so useful a purpose as it might. Some executives studied their recorder charts; many did not. And operators in general complained that it was no benefit to *them* to know what happened yesterday! This attitude extended further, however, as often the operator did not care what happened in the process preceding his station, or the following station either. This resulted in see-saw action in the majority of plants. In fact, many plant superintendents chalked up as a red-letter day any period when the process operated smoothly.

Instruments have, of course, developed from the simple indicating thermometer, water gage glass, and pressure gage, then the recording thermometer, gage and millivoltmeter pyrometer, through to the highly precise and rugged potentiometer, flowmeters and a host of multiple-function instruments. To-day instruments are available for measuring and recording almost any imaginable function, and for controlling almost anything that can be measured.

Now then, why do we not make better use of these functions? With a process to be controlled, and the instruments with which to control it, the procedure should be as obvious as in the case of having some sand and a rat hole. The difficulty in this case is that one party (the instrument manufacturer) has the sand, and another party (the customer) has the rat hole. The difficulty is getting together.

In what follows, the writer does not pretend to be "a voice crying in the wilderness." Rather, he hopes to be expressing the feeling of most thoughtful observers.

Usually when the design of an industrial plant is under consideration, instruments are the last consideration. How often has an instrument salesman heard, "We are not ready to talk about instruments, but you might leave us a catalog on thermometers." . . . "Come back in sixty or ninety days."

Now instrumentation is too vital a thing to be left until the last. Instrumentation, properly applied, is not only the eyes and ears of management; it is also the hands of the operator, and in some cases an efficient watchman. If you were designing an automobile you would not regard the application of steering gear and brakes as an afterthought.

Usually, when an instrument salesman approaches a customer, he may inquire, "What thermometer do you want, what chart, how much tubing, how many flowmeters, what kind of control?" This procedure is hoary with age, and that is about the only justification that it has. Ordinarily, the customer does not need to know exactly what particular variety of instrument he wants; and he usually does not care. What concerns the customer is the results he wishes to accomplish. He may or may not know the characteristics of liquid-filled, vapor-tension, or gas-filled thermometers. He *does* know what the temperature of the process is, and what the range is, also the distance from the point of measurement to the recorder location. Now it is up to the manufacturer's engineer to decide which of the three systems is best suited to the job. Of course, if the customer is dealing with a manufacturer who does not make all three systems, the element of danger is obvious.

Instrumentation is just as vital a consideration in plant design as the selection of the equipment itself. Some process equipments are susceptible to instrument control, others are difficult. In general, continuous processes handle better than batch processes. Yet in many plants we find batch processes where the flow of material should be continuous. Batch processes require different treatment, yet it is possible to integrate them into a continuous flow sheet. Equipment can be much more intelligently selected, after basic instrumentation has been decided upon. At this point we need the services of a man who knows something of process limitations, and of instrument capabilities. And we don't want a flowmeter expert or a thermometer expert. He will be about as much use as a bathtub designer in an architect's office. Let us call this man an instrumentation specialist or an application engineer, or anything else you wish. In addition to the foregoing requirements, he must also possess the unusual ability not only to visualize a process or manufacturing operation, he must also be able to extract from the operating staff, sometimes painfully, just what is to be accomplished. As yet it does not particularly matter whether this man is working for the instrument manufacturer or for the customer. (Usually, if he is good, the manufacturer will pay him more than the customer will, anyway.)

The true function of the instrument application engineer is to visualize the plant operation as an integrated and coördinated procedure and then act accordingly. If the various phases of a particular part of the process are critical, then certainly the whole operation of the plant is also critical. The present trend, the writer believes, is toward integrated control, for the reason that it is the only logical way of applying instrumentation. The present practice in petroleum refining is illustrative. In this case the exigencies of the process have demanded integrated control. Here we have all the measuring and controlling instruments vital to a process brought to one board. One man, sometimes called a plant operator, or a process operator, is charged with the responsibility of maintaining a smooth operation, within, of course, the limits of capacity of the process equipment itself. He sets the control points as needed to maintain stability. This does not entirely dispense with attendants at the machines but it does assure the equipment being operated in the way intended.

This same method may be profitably applied to many other industries. You have only to go into a plant and find the plant superintendent galloping from one end of the plant to the other in an attempt to find out what is going on, to see where the need lies for intelligent instrumentation.

The writer advocates the broad viewpoint toward instrumentation that has for years been preached by *Instruments* and by the more progressive manufacturers of instruments. The first thing required is a broader viewpoint on the part of the instrument salesman, for *he* is the one who must tell the story. First he must get a picture of the operation, of the things to be accomplished, and the dangers to be avoided. At this point, as mentioned before, the thermometer specialist or the flowmeter specialist is of little help to us. We need now our application engineer.

Fundamentally he must ask a set of questions different from what he has usually asked before. For instance, let us assume a hypothetical job, not particularly related to any industry. Our design job will go about as follows:

First we shall list the critical points of the process—the points at which trouble is quickly reflected forward and backward through the system. In the sugar industry these points are usually the diffusion batteries, carbonators, evaporators and white pans. We may find, depending on the plant and process, that there may be one or two such points, or there may be a half-dozen. *(Continued on page 167)*

Hardness Tests on Various Non-metallic Materials

By S. R. WILLIAMS
Professor of Physics, Amherst College

If hardness is a physical property, it must be universal for all solids and we need to think of hardness in connection with solids other than metals, whether that be the hardness of wax, wood, minerals, or the protective coatings we find in paints, lacquers, shellacs, plastics and electrical insulating materials. Even candies, fruits, cold butter and ice cream need hardness tests to insure proper sales values.

Due to the fact that metals play such an important role in our industrial life, previous chapters have emphasized the hardness measurements of metals. While the hardness values of a number of non-metallic substances have already been discussed, a few more materials will now be taken up, one by one—chiefly to bring out the great variety of the problems of hardness testing.

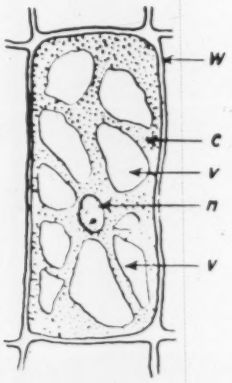


Fig. 254. A Typical Living Cell of Wood.
w—cell wall
c—cytoplasm
v—vacuoles containing cell sap
n—nucleus

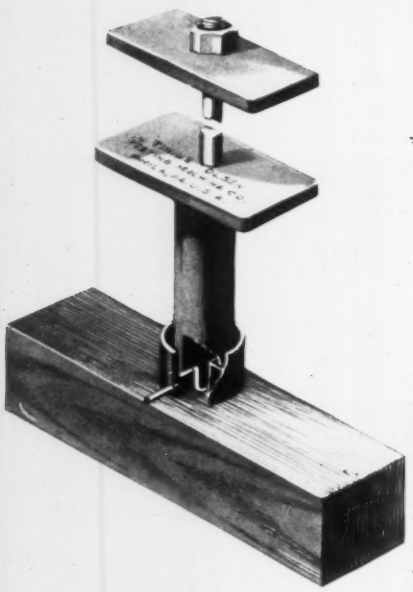


Fig. 255. The Instrument shown here is used for Testing the Hardness of Wood. Standard Tests are made on 2-inch x 2-inch x 6-inch Specimens. The above Tool is constructed to meet the A.S.T.M. specifications for such Tests.

WOODS

The hardness of woods depends largely on the cellular structure of the material. See Fig. 254. For this reason the study of the hardness of woods adds to our ideas of what constitutes hardness. So far as the cell wall is concerned, that now appears to be crystalline in its structure. This is shown by X-ray analysis.[1] Wood with small cell cavities and thick cell walls will, in general, show high hardness numbers. This variation in cell structure shows why spring growth in wood is softer than summer growth. See Fig. 31.* Lignum vitae is a good illustration of a hard wood while Balsa furnishes a good example of a soft wood.

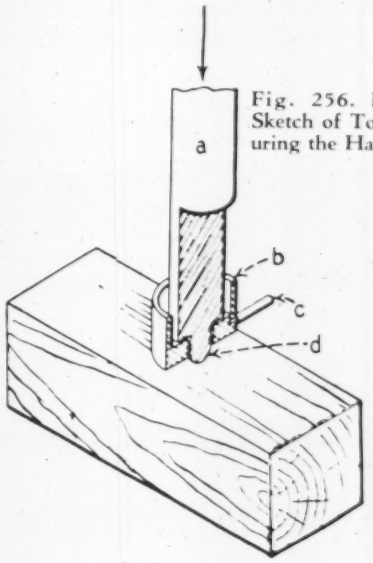


Fig. 256. Diagrammatic Sketch of Tool used in measuring the Hardness of Wood.

The firm of Tinius Olsen, Philadelphia, manufactures a device for measuring the hardness of wood. This is shown in Fig. 255, while Fig. 256 indicates more clearly the manner in which it works. The hardness is measured as a function of the load and the rate at which the hemispherical ball penetrates the material until the steel shoulder above the ball-ended penetrator meets the stop-plate. The hardness of the wood will depend upon whether the hardness numbers are taken on the ends of the fibers or on their sides, being greater on the ends than on the sides.

*May 1937 instalment.

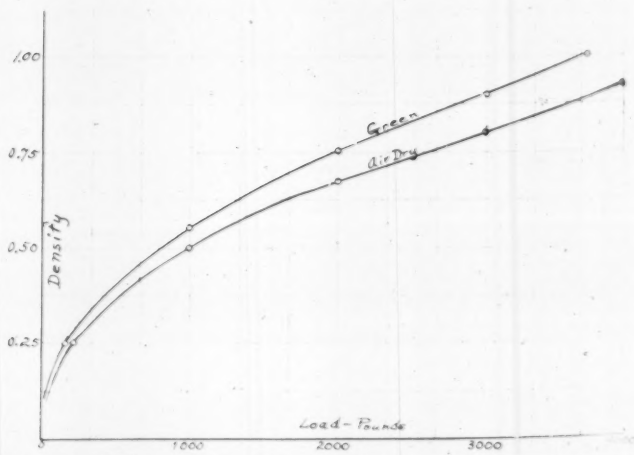


Fig. 257. The Variations in the Hardness of Woods with their Density.

[1] O. L. Sponsler, The Molecular Structure of the Cell Walls of Fibers, *American Journal of Botany*, Vol. 15, 1928, pages 525-536.

It [illegible] compares the hardness numbers of various woods with their corresponding densities they appear to vary approximately as the squares of the densities. This is shown in Fig. 257. In these curves the hardness numbers have been taken on the ends of the fibers. A corresponding relation holds for the hardness numbers measured on the sides of the fibers. The wearing quality of wooden paving blocks is greater when the fibers are set on end.

PARAFFINES AND WAXES

Here is a field that needs a great deal of investigation, not only as to the constitution of the paraffines and the waxes, but also as to the methods to be employed. As in the case of the plastics dealt with in a previous chapter temperature plays an important role.

If one takes ordinary commercial paraffine and pushes a steel ball into it under a given load, the behavior of the paraffine will be found to differ greatly from that of most other materials. The paraffine behaves as though it became liquid in a layer directly adjacent to the ball and squirts out around the ball in a thin film and forms fantastic curls of the material. This is shown in Fig. 258. When a small amount of beeswax is added to the paraffine the extrusion around the ball no longer occurs and a piling up indentation is formed.

This whole field is now under investigation, for the hardness of various waxes is an important subject.

RUBBER

Several devices have been manufactured to meet the specific needs of those who wish to keep in line with standardized tests for soft rubber. Fig. 259 shows an instrument put out by Schopper of Leipzig, Germany. A hardened steel ball, 10 mm. in diameter, is applied to the surface of the soft rubber under a load of 1 kg. The hardness number is then given by the depth of penetration in fractions of 1/100 mm. after 5 seconds and after 30 seconds.

Fig. 260 shows an instrument produced by the same firm for measuring the hardness of hard rubber, vulcanite and other insulating materials. In essentials it is a Brinell hardness tester applied to the hardness tests of plastics.

In this instrument is to be found quite a range of loads which can be applied to the 5-mm. steel ball used as an indenter. The compressive force is supplied by suspended masses of 5, 10, 25 and 50 kg. These are attached to

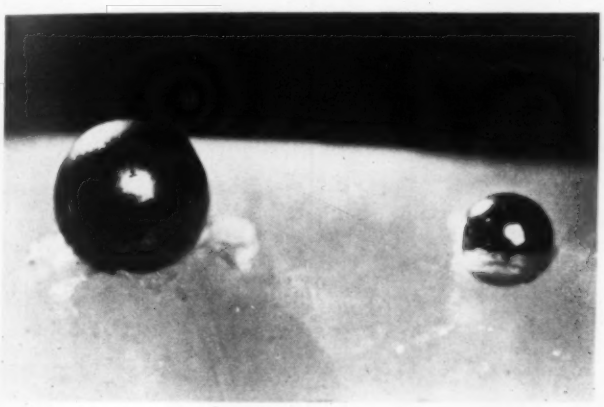


Fig. 258. Extrusions of Paraffine around a spherical Indenter.

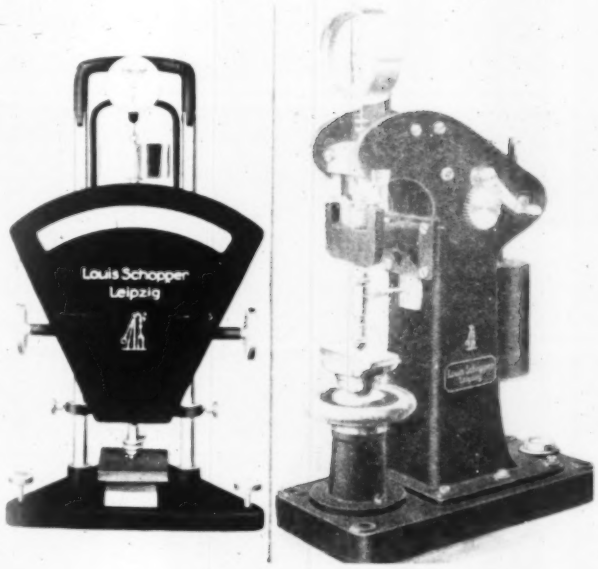


Fig. 259 (left). Schopper's Hardness Tester for Soft Rubber.
Fig. 260 (right). Schopper's Hardness Tester for Hard Rubber.

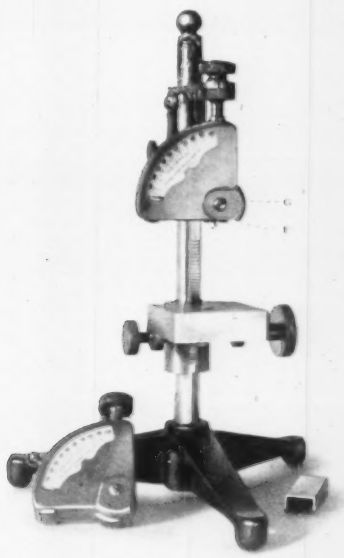


Fig. 261. Shore Instrument for testing hardness of Rubber.

a compression beam balanced on knife-edge bearings and the load is transmitted to the compressor head. The hardness number is read from a dial indicator gage which gives the depth of the impression to 1/100 mm. The depth of the impression is measured after 10 seconds and after 60 seconds; and the Brinell hardness is calculated from the depth of the impression, or by referring to tables specially compiled for the purpose.

While we may not know the chemical constitution of the rubber, we have, at least, been able to standardize the various grades of rubber and hence the hardness numbers for the different forms of rubber.

Fig. 261 shows another design of a hardness tester for rubber. It is put out by the Shore Instrument Mfg. Co. and is one of the Shore devices known to the trade as Durometers. An operating stand is provided with each instrument, but it may be used as a portable instrument, and held in the hand.

The instrument contains a miniature beam weigher scale, against which a compressor pin works as it indents the rubber. The beam in turn works against a

THE ALL PURPOSE

AIR VELOCITY METER

INSTANTANEOUS DIRECT READING

No longer is it necessary to use complicated instruments and stop watches or make slow, mathematical calculations to obtain accurate velocity readings of irregular shaped or slotted grilles; velocity readings in ducts or at inlet or outlet openings of other air velocity measurements.

With the "Alnor" Velometer, the instantaneous direct reading air velocity meter, you can obtain these readings accurately, conveniently and quickly. You can check static or total pressures, locate leaks and losses, detect drafts, or determine efficiency of fans, filters, blowers and other equipment.

The Velometer gives instant air velocity readings directly in feet per minute from as low as 20 F.P.M. up to its maximum scale reading. Ranges up to as high as 18,000 F.P.M. velocity and 20 inches static or total pressure are now available.

Write for New Folder No. 2448-B

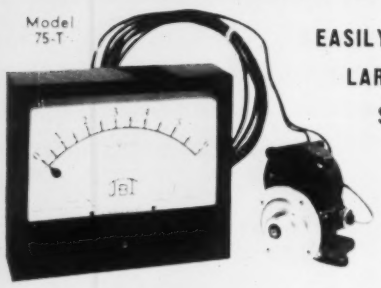
See "Alnor" instruments on display at the American Foundrymen's Association 44th Annual Convention, International Amphitheatre, Chicago, Illinois, May 4th to 10th, 1940.

Illinois Testing Laboratories Inc.

142 W. HUBBARD ST., CHICAGO, ILL.

J-B-T Electric Tachometer

Model 75-T



EASILY INSTALLED

LARGE, OPEN SCALE

SMOOTH READING

●Dynamometer test work, output of paper and loading machinery, and speed of propeller shafts are typical of the widespread application of this direct-current indicator and magneto. (See description in editorial columns.)

Constant in calibration, compensated for effect of ambient temperature, Model 75-T gives important information with one or more instruments connected to the same magneto.

Operators like the 6" scale, drawn to their requirements, for its virtually uniform divisions and smooth following of speed at any point on the scale. Engineers approve the sturdy design, flanged magneto collar for simplified installation, and ease of connecting by copper wire of the length desired.

Maintenance men appreciate the dust- and splash-proof features, lac'k of wear in mechanical parts, years of trouble-free operation.

Quotations gladly sent on request.

Other J-B-T Products For Your Applications

Model 70-PO, the new potentiometer-pyrometer without standard cell, reads temperatures at atmospheric ranges of up to 0-3000 F. by means of thermocouples. Withstands vibration and marked changes in ambient temperature. Requires less balancing than conventional types.

Noteworthy, too, are the thermoelectric pyrometers, automatically compensated. Scale lengths 2⅝" to 6½"; ranges 0-600 F. and up; for wall, panel, or switchboard. Available as resistance thermometers for lower temperatures.

Also ultra-sensitive double-pivoted galvanometers. Thermocouples, selector switches, and accessories.

Write for Data

Dep't I, 441 Chapel St.

J-B-T

J-B-T INSTRUMENTS, INC.

New Haven, Conn., U. S. A.

standardized resistor spring and the movement of the compressor pin is measured by a pointer which moves over a quadrant dial indicator scale.

RIPENESS OF PEACHES MEASURED BY HARDNESS GAGE

There seems to be no limit to which the indentation method may be applied. In *The New York Times* for August 23, 1936, appeared headlines that the ripeness of peaches could be told by an indentation method. A plunger works against a spring and when a pressure of 9 to 10 lbs. is indicated, as necessary to penetrate the fruit, it shows that the flesh of the fruit is firm enough to stand long-distance shipping. If the reading on the scale is only 3 lbs. when it penetrates the flesh of the fruit, it is indicated as "soft ripe" and should be eaten as soon as picked.

Other points on the arbitrary scale are "firm ripe" which tells the need for immediate harvest and marketing; "hard ripe" peaches can be held at the market for second-day sales; and "near-by-shipping ripe" are for markets within a few hundred miles.

The development of new and improved varieties of peaches has made color, the old basis for ripeness, an obsolete method. Such developments are as they should be, because it takes the guesswork out of judging as to when the fruit should be picked for certain purpose, i.e., the suitability of the fruit for a definite use.

STONES

There is an urgent need for research work in the measurement of hardness of commercial stones, for example, granite, marble and slate. The lack of clarity as to what we are measuring in the ordinary use of a hardness tester makes it apparent that there must be just now hopelessly conflicting conceptions of hardness in the field of commercial stones. There even seems to be no reliable method at present for measuring these hardnesses. The first step in the program of research would be a testing of methods. For instance, how would Bierbaum's Standard Instrument work in this field?

Lord Kelvin voiced the proper attitude toward research when he said: "I cannot doubt but that these things, which now seem to us so mysterious, will be no mysteries at all; that the scales will fall from our eyes; that we shall learn to look on things in a different way—when that which is now a difficulty will be the only common sense and intelligible way of looking at the subject." In other words, Kelvin called for research and investigation of the mysteries of the unknown and hence of hardness. Eventually we shall know.

In a personal letter Mr. Harold Ladd Smith, Director of Research for the Vermont Marble Company in Proctor, Vermont, has set forth in a clean-cut way the conflicting conceptions of hardness in the field of commercial stones. With Mr. Smith's consent a large part of his letter is herewith given:

1. *Architect's Interest*

To the architect specifying a flooring material, "hardness" means the resistance to abrasion wear. He may want to gage the comparative wear of marble tile and a rubber composition or linoleum covering. Any one unit of the measure of hardness in such divergent materials seems out of the question. Or he may simply want to select a mixture of marble tile and border to produce a decorative effect and to have some assurance that they will wear evenly. This is justifiable and disregard of this problem has led to horrible examples installed in the past. Unfortunately the architect's interest in color and design may lead him to ignore such abrasion data as there is and the advice of reputable producers who are able to profit by experience. Furthermore, actual wear will vary somewhat with each installation and the cleaning or maintenance methods.

...ent methods for determining comparative wear of dif... marbles produce coefficients that are misleading and of ...tal value. Machine test abrasion, utilizing a steel lap and ... of silicon grain, does not duplicate actual wear of ...e material tracked in on shoe leather. The tearing action ... one hand and the rolling abrasion on the other give ...ent results. Such a machine verifies the obvious fact that ...pentine marble is harder than a pure calcite but the com...tive gradation of similar materials does not agree with ...dable installation experience. Furthermore, it does not ... that a stone testing "0.20" will have double the resistance ...rasion of one with a wear coefficient of "0.10."

2. *Owner's Interest*

To the owner of a decorative marble installation, "hardness" means the ease with which the marble is scratched. Relatively pure calcium carbonate stones presumably have a uniform hardness as shown by Mohs' scale. But a coarse crystal stone will apparently scratch easier than one with fine crystals and equal abuse will appear worse on a dark colored stone than on a light one.

3. *Monument Purchaser's Interest*

To the purchaser of the monument and the memorial dealer, "hardness" means the ability of a stone to withstand weathering exposure. They have a vague idea that because granite is "hard" it will weather better than marble which is spoken of as "soft." Actually hardness in that sense has little relation to durability, for rocks testing high according to Mohs often disintegrate more seriously than stones lower on the scale. Resistance to weathering may vary with absorption, crystal structure, locality, fabrication methods, and the orientation of the crystals on the exposed faces.

4. *Marble Worker's Interest*

To the producer or finisher of marble, "hardness" refers to the workability of the material, the action on the channeling, drilling or cutting steel, the sharpness and permanence of the arris on the stone, etc. This will vary with the personal equation of the cutter, the air pressure, condition of the tools, etc. Marbles of differing "hardness" require different grades of "hardness" in the abrasive bricks used in finishing. (And incidentally mechanical tests on artificial abrasive bricks seem to bear no relation to brick wear, speed of cutting or resulting finish on marble. One head of bricks graded "J," for instance, may last three weeks, cut well and produce a good finish, while another head similarly graded "melts" away in a day or two and leaves a coarse finish.)

5. *Factors Involved*

So-called hardness in stone seems to be concerned with:

a. Crystal size and its uniformity.
b. Degree of irregularity in crystal shape and its interlocking structure.
c. Natural absorption of the stone and the width of the intercrystalline space.
d. Orientation of crystal structure.
e. Hardness of individual minerals.
f. Fabrication methods.

and all of these are of varying importance depending on the conception of "hardness" being considered. Such properties as penetration, scratchability, resilience, machinability, uniformity, etc., are involved.

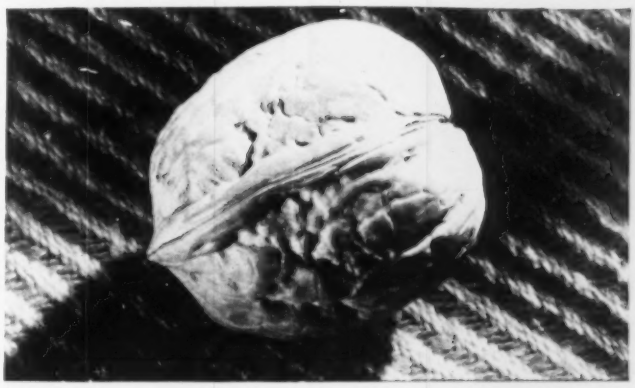
Behavior in use is the final test but results are always comparative and there is no acceptable standard at present.

CORRECTION

In last month's instalment of this series by Professor Williams, a line of type was dropped out of the last paragraph on page 135. It should read as follows:

Under this condition of strain twenty or more strips of the watch spring were subjected to intense magnetic and electric fields. No breakage occurred. What other factor could be present in a thunder shower to increase breakage? Evidently moisture, and if this moisture is due to the humidity at times of thunder showers, then the breakage must be seasonal. Accordingly the record

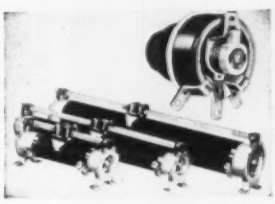
RHEOSTATS



THE WHOLE STORY IN A NUTSHELL

Plate Type Rheostats Single, Multiple, Manual and Motor Driven.

Face Plate Type for extremely heavy current services.



Wire Wound Rheostats in tubular and small ring types.

Ward Leonard Rheostats cover a range from the small types for fractional horsepower motors to the largest multiple units to control the heavy current requirements of rolling mills. The bulletins covering the types, drives, mountings and accessories of the Ward Leonard Line is the whole story of Rheostats "complete in a nutshell." Send for Rheostat Data Bulletins.

Bulletin No. 60

Describes pressed steel, cast iron and face plate types, combinations, drives and accessories.

Bulletin No. 1105

Describes ring type rheostats 30, 50, 100 and 150 Watt Ratings.

Bulletin No. 8002

Describes Laboratory Rheostats with and without micrometer-drive.

WARD LEONARD

ELECTRIC CONTROL DEVICES SINCE 1892

WARD LEONARD ELECTRIC CO.
38 South Street, Mount Vernon, N. Y.

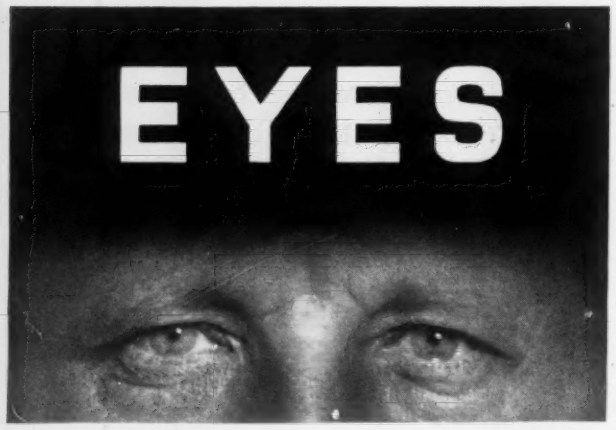
Please send me complete set of your latest Rheostat Bulletins

Name.....

Firm.....

Address.....

City..... *State*.....



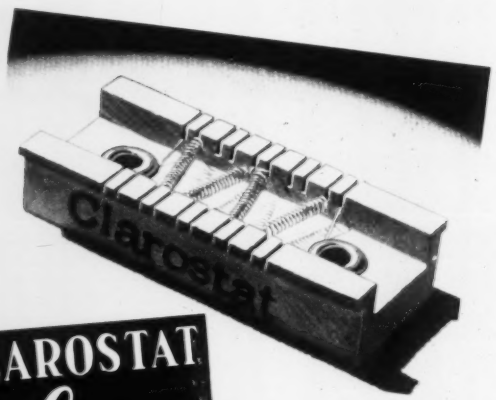
Require Magnification in Order to Check Production Accuracy

Checking dimensions which must not vary more than one or two thousandths, and even only a few tenths of thousandths of an inch, requires something more discerning and faster than the human eye. A Federal Dial Indicator is the answer. *Investigate*

Send for Catalog

FEDERAL PRODUCTS CORPORATION
PROVIDENCE, RHODE ISLAND

FEDERAL
PRECISION MEASURING INSTRUMENTS



Special igniter for gas-operated furnace — a lot of heat in a small space.

Let CLAROSTAT Solve YOUR RESISTANCE PROBLEM

★ A gas-fired furnace manufacturer needed an igniter resistance. Element to attain 1850 F.—bright red—in 5 seconds, at 20 volts, 40 watts.

Clarostat solved the problem with this special unit. Lava body; freely suspended windings of high-temperature alloy; steel eyelet terminals.

Clarostat spent many times more for this development than amount of initial order. But—there's more business coming because user is fully satisfied.

The large furnace manufacturer saved thousands of dollars because of this Clarostat service.

You too can have this specialized engineering service. Just send us your problem. And be sure you have our loose-leaf engineering data on hand.

CLAROSTAT Manufacturing Co. INC.
285-287 NORTH SIXTH STREET
BROOKLYN, NEW YORK, U.S.A.
• OFFICES IN PRINCIPAL CITIES •

Instruments for "Logging" and Sampling Wells

(Concluded from page 156)

the reading of the pump stroke meter may be read from the chart for any depth. One may then count back the number of pump strokes required to bring the sample up from the bottom, and read directly the depth from which the gas show originated.

Since it is possible that the drilling may have stopped at the time of a gas show, arrangements are made also to indicate on the pump stroke line the exact time of a gas show, so as to give a point from which to count back.

ADDITIONAL EQUIPMENT

The trailer is equipped with a complete core analysis equipment including a permeammeter of novel design, as well as equipment for porosity measurements and water determination. A new device is now being perfected and tested to give direct readings of gas content of core samples.

The trailer is fitted out also with a complete set of instruments for routine mud testing. This enables the operator of the trailer to keep a constant check on the characteristics of the drilling mud in use at the well and thereby greatly facilitate the drilling operations.

The logging instrumentation described above may be used either for continuous logging of wildcat wells or merely for completion of wells in known sands. When used for continuous logging at a wildcat well, it compares with continuous coring but is, of course, much faster, and does not interfere with drilling. Naturally there is a lag between the drilling of a sand by the bit and the arrival of the sample at the surface. If, therefore, it is desired not to enter a producing formation farther than a certain depth, drilling may have to be slowed down. For instance, suppose in a well 5,000 feet deep, it is not desired to enter the sand more than 10 feet. At this depth, returns are received at the surface about 30 minutes after they pass the bit and drilling consequently has to be slowed down to 20 feet an hour if it is not desired to go more than 10 feet into the sand. (Under the same requirements, but with coring, this speed would require the taking of two 10-foot cores per hour which is, of course, quite impossible.)

Examples of the second type of operation, wherein it is desired merely to complete a well in a known sand, are the wells completed by this method in one of the Gulf Coast oil fields. In this field it had been the custom to start coring 50 feet above the sand and take 5-foot cores until the sand was reached, the operation taking from two to three days. When mud logging was substituted for coring in this field, the trailer was hooked up when the well was 50 feet above the sand and drilling continued normally until gas was picked up some 10 or 15 feet above the sand, whereupon drilling was slowed down to 10 feet an hour and the top of the oil sand determined. (This whole operation—from 50 feet above the sand to completion—seldom took more than three hours as compared to two or three days by the coring method.)

It is important to note that the additions to the mud that this logging method serves to detect are obtained from the pores of the actual cylindrical core drilled by the bit, and not from inflow from the surrounding strata. Should inflow occur, this logging method would be next to impossible to employ, because inflow would continue after the bit had passed through the horizon concerned. Experience with the method has shown that inflow seldom occurs. This finding coincides with theory, since the pressure in the hole due to the column of mud exceeds that in the formation under normal drilling conditions. Occasionally false shows have been obtained due to inflow, but with one exception they occurred immediately after a round trip (which easily can be accounted for)—the one exception being a strong gas show which appeared a short time before a blowout.

Beside the benefits heretofore specifically mentioned, observing operators gather much additional information on

...cable value in properly drilling a well and minimizing ...enses. The proper use of this well logging service sho... practically eliminate blowouts.

T... trailers are offered to the industry by Baroid Sales Di...on, under exclusive license from Barnsdall Research Co...ation, who hold patents issued or applied for covering ... instruments and processes used. The instrumentation equipment is manufactured,* assembled, and installed in ... trailers by Engineering Laboratories, Incorporated, Tu..., Oklahoma, where facilities are maintained for service and repair on the component instruments.

*Except, of course, individual instruments—such as the ones which *Instruments* readers recognize at a glance.—EDITOR.

Cathode-ray Tube Application Contest

A prize contest open to engineers, physicists, laboratory workers, servicemen and others, dealing with new and practical applications of the cathode-ray tube and allied equipment, is announced by **Allen B. Du Mont Labs., Inc., Passaic, N. J.** Contest opens June 1st, 1940, closes May 31st, 1941; is open to everyone regardless of position, title, academic or engineering qualifications.

Contestants may submit any number of papers, but only papers dealing with actual applications of c-r. tubes, oscillographs or other c-r. equipment, are eligible. Theoretical discussions, contemplated projects or mere suggestions cannot be considered. The application, however, may be in any field.

Subject matter alone will be considered. Contestants can express themselves as best they can. Photographs, drawings and sketches will count heavily but are not essential if text is sufficiently explicit.

Outstanding authorities in the cathode-ray field will act as judges, and their decisions will be final. All papers will become the property of Allen B. Du Mont Labs., Inc., and none can be returned.

Papers accepted for publication in the Du Mont monthly *Oscillographer* will receive an honorarium of $10.00 per paper. In addition, there will be awarded three grand prizes of $100.00, $50.00, and $25.00, for the three best papers submitted during the Symposium.

Wanted—Broad View of Instrumentation

(Concluded from page 161)

Second, we list other points that should be controlled. Then we list those points that need be recorded only. Next we must give attention to the batch cycles, if any. Next we designate the temperature, density, or ratios, timing, speeds or velocities.

Now we go through our list again. We select all those functions that should be controlled within a range of 2%; then, those points that can stand a 5% to 10% variation. Next, estimate process lag and provide methods of compensation.

First select those processes where lag is slight and narrow throttling range will be sufficient. Next take the points where the controlled condition must be kept "right on the nose" in spite of process lag or sustained load changes. These points will require controllers with automatic reset, and perhaps manual response-rate adjustment.

At last now we are down to the first question asked by our mere salesman: "What chart?" We now select chart ranges. After chart ranges we next consider measuring systems. In the case of temperature we have three, or in some cases, four choices of measuring system in the thermometers, as well as resistance thermometers and pyrometers. For measuring flow we have orifices, nozzles, Venturi tubes, Pitot tubes and other kinds of devices, in combination with mercury manometers, as well as bell float types and other special devices. Pressure and liquid level measuring systems are legion and offer a wide choice. These questions apply equally to controllers, recorders and indicators.

In general, the selection of the measuring system depends on the process and almost equally on the process auxiliaries, that is, on pumps, fans, furnaces and the like. Close study

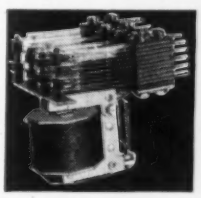
RELAYS by GUARDIAN

. . . for AC or DC Operation—

★ Relays—Solenoids and Stepping Switches illustrated below suggest a few of the numerous types of Electrical Control Units obtainable at Guardian Electric.

If you need COMPACT and highly sensitive controls that possess quick responsiveness and precision of action—with MAXIMUM CONTROL in *minimum space*—you will get it ALL at Guardian. Controls by Guardian are furnished to operate on any specified voltage up to 220 DC—440 AC—and on any current from .5 milliamperes to 30 amperes. Contact capacities to 1500 watts.

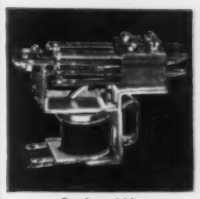
ALTERNATING CURRENT RELAYS



Series 30

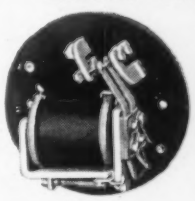
Series 30 (left) Supplied in three types of mountings, voltage range 1 to 110 volts, contact capacity 12 contacts. Size 2¾x1½x2½.

Series 110 (right) Compact, economical, widely used unit. Four pole, double throw contact capacity, 220 volt limit. Size 2¾x3⅞x1 15/16".



Series 110

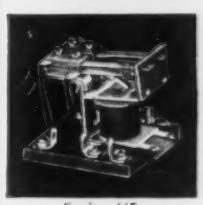
DIRECT CURRENT RELAYS



Series 5

Series 5 (left) Current draw as low as .005 watts—furnished completely enclosed—contact limit, double pole, double throw. Size 3¼x3¼x2"

Series 115 (right) Four pole, double throw contact capacity, rapid change over of contacts, full floating, permanently locked armature, economical of space and cost.



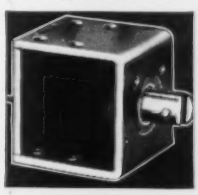
Series 115

S-T-E-P-P-I-N-G RELAYS

Versatile, advanced designs, simple in principle. New applications for these units are appearing constantly giving circuit control hitherto thought impossible. Rigidity of construction guarantees long life. Innumerable variations available.

Type-R Stepping Relay

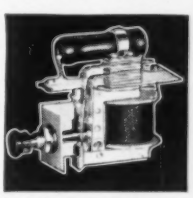
Type No. 2



SOLENOIDS—AC; DC

Type No. 2. Efficient—powerful—compact. For electromechanical operations involving remote control of mechanical motions such as electric counting, valve control and operation, faulty material ejector, automatic brake, electric racheting, etc. 1½x1½x1⅝.

Overload Relays



Positive, precise protection against current surges, continuous overload. Manual reset. Size 1x2½x3½.

RF Relays Type R-100

Single or double pole, single or double throw, relay with coil wound for 110 volt or 6 volt—60 cycle AC. For high frequency applications.

*WRITE TO GUARDIAN for free engineering assistance on any electrical control problem. No obligation. Ask for Big 1940 Catalog L, with illustrations and specifications on our complete line.

GUARDIAN ELECTRIC

1621 West Walnut Street Chicago, Illinois

of auxiliaries, that is, on pumps, fans, furnaces and the like is required to coördinate instrument characteristics with auxiliary characteristics. Coördination with process equipment characteristics has already been attained.

Next, location and arrangement of the instrument board, or boards. Also the selection of air, electricity or hydraulic power. Then the control valves, dampers, speed regulators and other devices for making the changes in the controlled conditions are decided upon, with due weight given to equipment as well as instrument characteristics. This completes the instrumentation, as regards the survey and recommendations of our application man. Now the instrument experts can get busy and design and build the instruments needed for all the applications . . . or ship them from stock in instances when standard models are called for.

In many cases, in approaching such a problem we shall find that the plant management may not have a comprehensive viewpoint on the operation. For instance, in the cement industry, it has in the past been the practice to carefully separate the peration into quarry, raw grinding, kiln room, finish grinding, and stockhouse. In many plants, it requires a great deal of effort to find out what is going on in the whole plant. Coördinated instrumentation would allow the plant superintendent to walk into the instrument room and see in a few minutes whether raw material was being ground as fast as the kilns were burning it, whether the fuel ratio was proper or improper, whether one department was using more power than it should; in short, the superintendent would have the whole picture of plant operation. Then he could spend his time in remedying trouble, instead of merely hunting it.

More valuable to the superintendent than past records, perhaps, is the fact that the records will show trends so quickly and enable the anticipation of difficulty. For instance, on a recent job, a large smelting company installed a six-point strip-chart multiple recorder on a large turboblower. This records steam temperature into the turbine, air temperature leaving the blower, oil cooler in[illegible] and outlet temperatures, blower jacket water temperat[illegible], and condensate temperature. A steam flowmeter, an a[illegible] flowmeter, and a recording vacuum gage complete the [illegible]anel. Naturally, as the oil cooler gets dirty the inlet an[illegible] outlet temperature lines tend to converge, and both rise, [illegible] that a definite warning is given of its trend. Likewise, an inspection of the trend of these records allows the power-house foreman and the master mechanic to keep [illegible] close check on machine performance and, to some extent, to schedule shut-downs. While this particular plant does not have nearly as much in the way of instrumentation as the designing engineers would like, yet they are steadily approaching the idea of coördinated control.

The writer believes that the time is now here when the industrial instrument industry must largely forget about instruments as individual pieces of mechanism and consider them as a part of an integrated fabric of operation. The whole operation must be visualized as being in a dynamic state of balance, with the instrumentation maintaining the balance continuously. This does not mean that labor is to be dispensed with. Labor is more important in this scheme of operation than ever before. A greater degree of ability may be required in many cases. For example, it does not require a great deal of knowledge for a man to stand at a hand valve on a pump inlet steam line and maintain the discharge pressure fairly constant. For this man to move up to the instrument board will require a change in his way of thinking.

This broad viewpoint of instrumentation integrated and coördinated with process characteristics must be obtained and applied in order to get the most out of process capabilities and to meet competitive conditions.

The function of instrumentation in modern industry has changed radically in recent years and has delivered a challenge which the instrument engineer must prepare himself to meet.

INSTRUMENTS' BOOK SHELF

The Pyrometry of Solids and Surfaces. By ROBERT B. SOSMAN. American Society for Metals, Cleveland, 1940. Cloth, 6 × 9¼ inches, 100 pages. Price $2.50.

Here is an admirable little book—only 96 pages of text printed in large type and with large photographs and diagrams, so that it can be read in two hours—but presenting *all* of the fundamentals of the subject so exactly described by the title.

As announced on the title-page, this book comprises "A Series of Three Educational Lectures presented to Members of the American Society for Metals during the Twentieth National Metal Congress and Exposition, Detroit, Michigan, October 17 to 21, 1938." Well-prepared lectures, as a rule, make easy reading. These three make fascinating reading. There's not a "dry" paragraph in the book.

Lecture I deals fundamentally and briefly with thermoelectric pyrometry, radiation pyrometry, photoelectric pyrometry and optical pyrometry. In fine, it introduces the subjects to be dealt with later in detail.

Lecture II, "The Pyrometry of Metals by Means of Thermocouples," contains a wealth of practical advice on homogeneity of couples, gradients, soaking-pit pyrometry, heat-treating pyrometry and other applications, including surface pyrometry with thermocouples.

Lecture III, "Radiational Pyrometry of Solids and Surfaces," likewise presents valuable up-to-date information including such recent developments as the high-speed pyrometry of surfaces, open-hearth roof pyrometry by means of recently brought out instruments, maintenance of standards, color pyrometry, etc.

The interval between the delivery of these lectures in the autumn of 1938 and their publication in the spring of 1940 was evidently devoted to meticulous editing. Quoting from Dr. Sosman's Foreword: "In preparing the Lectures for publication, a number of illustrations, and certain descriptions of instruments and applications, have been omitted." Final result, the quintessence! In other words, a "MUST" for every *Instruments* reader whose work involves the measurement of the temperatures (above 900°F. or so) of solids and surfaces.

Dr. Sosman is an internationally-famous pioneer in the fields of thermometry and pyrometry, but the foregoing recommendation would have been equally fervent if the author had been unknown, because the reviewer some ten years ago wrote a book on temperature measurement and therefore is able to spot a first-rate job of writing on pyrometry regardless of who wrote it!

A classified bibliography and a subject index complete this extraordinarily useful accretion to the literature of Instrumentation.

—M. F. BEHAR

Introduction to Contemporary Physics. By KARL K. DARROW. Second Edition. D. Van Nostrand Company, New York, 1939. Cloth, xii + 648 pages. Price $7.00.

Appearing about thirteen years after the first edition bearing this title, this second edition is nevertheless a completely new book. This is quite obvious, since the author regards as "contemporary" the period beginning around 1910 and had now, therefore, a much longer time interval to deal with than in the 1926 edition. As the title of the book does not tell too much about its contents, it may be said that it is a treatise on atomic and nuclear physics, including a detailed description of the elementary particles.

Dr. Darrow presents his subject from a present-day view point, using the historical development only occasionally. Thus, after a short description of the "corpuscular" aspects of electrons and ions and a brief account of the nuclear atom model, he discusses the correlation of corpuscles and waves and introduces the principles of wave mechanics in an early chapter. This is followed by a chapter on the diffraction of waves by crystals, showing the similarities in the behavior of rays of light, electrons and material particles like atoms and molecules as direct evidence for the dualism of wave and corpuscular properties. The following chapters deal with ionization, stationary states of atoms, analysis of spectra, the original atom model of Bohr and its successors in wave mechanics, and with magnetism, electron spin and their influence upon spectra. The last four chapters give a review of nuclear physics including developments up to the beginning of 1939.

Throughout the book, emphasis has been laid upon the results of experiments and their relation to the predictions or conclusions of theories. Less space has been given to the details of the theories themselves, especially when, as in the case of nuclear theory, the author does not consider them to be final. As always, he has taken great pains to formulate concepts and definitions as precisely as possible and to point out weak spots in theories and arguments.

Written with great clarity and freshness of style, this remarkable book will be of great value for all those in-

New

MODEL 1290

TRIPLETT

INDUSTRIAL ANALYZER

$46.67 DEALER NET PRICE

Simultaneous readings of A.C. Voltage and Current can be made with the new Model 1290 Triplett Industrial Analyzer. Among other advantages, this feature makes it much easier to instantly locate Voltage Drop in any part of the circuit. Testing facilities of the Model 1290 include: FOUR A.C. AMMETER RANGES—0-1.5; 0-3; 0-15; 0-75. TWO A.C. VOLTMETER RANGES—0-150; 0-750.

Separate A.C. instruments are incorporated in the twin case. Both carry the exclusive Triplett RED ● DOT Lifetime Guarantee against defects of materials or workmanship. Designed for the utmost utility and portability, the tester has a detachable handle and removable cover with space for leads. The metal case with black suede baked enamel finish is 7⅞"x6½"x 5⅝". The heavy bakelite panel is a safety feature.

Model 1290 Industrial Analyzer, including leads: Dealer Net Price $46.67

For More Information—Write Section 326 Harmon Drive

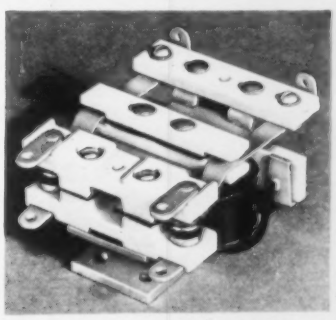
THE TRIPLETT ELECTRICAL INSTRUMENT CO.
Bluffton, Ohio

PRECISION CONTROL

PRECISE

Chemical analysis of magnetic material
Heat treatment for magnetic properties
Coil winding, coil treatment and assembly
Test and inspection

This new "25 relay"—rugged, compact, foolproof—has a low power consumption of 1.5 watts and high power output of 2,000 watts. Developed to fill the need for a high quality medium duty relay at low cost. Coin silver contacts—¼" diam. Alsimag non-hygroscopic insulation, cantilever spring action, self cleaning wipe.



Cut production as well as experimental costs—specify Kurman relays for the next job. Write for descriptive literature; no obligation.

KURMAN ELECTRIC CO.
INCORPORATED
241 Lafayette Street, New York, N. Y.

ested in the development of modern physics. Beginners might find some chapters rather difficult, but will find most of the book easy to understand, and even "experts" will certainly find some new and useful material. A five-page subject index and a six-page author index, as well as the many illustrations, add greatly to the book's value. Some typographical and other errors have crept into it, but most of them are so obvious that the careful reader will note them easily.

—I. ESTERMANN, *Associate Professor of Physics, Carnegie Institute of Technology.*

Mathematical Snack Bar. By NORMAN ALLISTON. Chemical Publishing Co. of New York. Cloth, 5½ × 8¾ inches, viii + 155 pages. Price $3.00.

Yes, a snack bar and not a heavy dinner-table. As deftly promised by the title, the reader has his choice of *hors d'oeuvres* and cocktails—fifteen of them—and he may consume any or all of them in whatever order his fancy dictates.

As far as is known to your reviewer, this is the first mathematical book ever published which, although written entirely by one author, is designed to be sampled here and there as one would sample a collection of miscellaneous essays by different authors. Sampled with delight by your reviewer!

In his preface the author explains that the "roving investigator in any branch of science" will have accumulated, after a quarter-century or so, "a certain amount of original material, the essence of which he would gladly make public. In any case . . . a fund of lesser results, inventions, turns, . . . "

Wholly free from higher mathematics, this little volume will be enjoyed not only by graduates of engineering courses that included the usual calculus and differential equations, but by technical workers who have "a head for figures," who naturally grasp geometry and who either had a good mathematics teacher in high-school or took a few correspondence-school courses in practical mathematics. In other words, most of Alliston's "inventions" and "turns" are geometrical and arithmetical; and they can be read with pure enjoyment by an audience many times larger than that which buys a new mathematical book for pure study.

So varied are Alliston's "snacks," and so forbiddingly dry his Table of Contents, that it seems best to let him describe his "bar" in a few of his own prefatory words:

"It features an abbreviated method for developing the series of values that make biquadratic expressions square; . . . a fresh solution to the age-old problem of the tangencies; . . . snatches at some few deducibles concerning prime numbers . . . analyzes the heronian triangle and retrieves some missed solutions in Diophantine problems. . . . On several of the subjects treated there are no general reference works, and contributions to them are scattered. . . . "—M. F. BEHAR

The Physical Examination of Metals, Vol. I—Optical Methods. By BRUCE CHALMERS. Longmans, Green & Co., New York, 1939. Cloth, 5½ × 8½ inches, 180 pages. Price $4.

The book outlines the latest adaptations of interferometers and polarized light to metallurgical work, and is therefore a timely exposition of principles, equipment and methods.

Some applications of optics are so well established that the author only mentions them, such as microscopy, pyrometry and spectrographic analysis. Also these subjects require extensive treatment in themselves. The book is primarily confined to measurement of the surface conditions of metals: smoothness, oxide layers, adsorbed gas films, passivity.

—RICHARD RIMBACH

Vector Analysis with an Introduction to Tensor Analysis. By JAMES HENRY TAYLOR. Prentice-Hall, Inc., 70 Fifth Avenue, New York, 1939. Cloth, 6 × 9¼ inches, x + 180 pages. Price $2.85.

This book is distinctly different from the usual vector analysis text: the development from the beginning is parallel to that commonly used in studying Riemannian Geometry and tensor analysis. It has the same relation to the latter subjects as the special theory of relativity has to the general theory.

The book is conventionally divided into four chapters: Algebra of Vectors, Differential Calculus of Vectors, Integral Calculus of Vectors, and Introduction to Tensor Analysis. But this is as far as its conventionality extends, for the first chapter includes discussion of affine coordinates and translations, groups, vectors, linear dependence, and linear transformations, in addition to the treatment of vector products and applications.

The quantities *divergence*, *gradient*, and *curl* are defined as the limit of the ratios of surface integrals to the enclosed infinitesimal volumes. This method of definition has the advantages that it clearly defines quantities which are independent of the coördinate system and that it makes possible a certain visualization of the meaning of these operators.

Numerous references are given at the beginning of each new subject. The printing is excellent, and misprints and errors are few. On page 97 it is stated that "Hence the vector *grad* **F** is normal to (1) the level surface and (2) points in the direction of F increasing. These two properties of *grad* **F** can be taken as defining the gradient." The statement is awkward because of the position of the number (1), and the two properties do not define a vector because they say nothing about magnitude. On page 119, in deriving a formula involving the operator del, it is stated that "Since in